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Science Review

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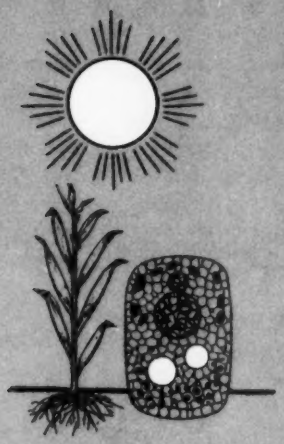
Conservation and Rural Development in Great Britain Page 1



AGRICULTURAL SCIENCE REVIEW

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No Room for Stereotypes

Some years ago this column carried an editorial titled, "Where Are the Eccentrics?" It referred to the nonconformists in science who earned a place in history because they dared to be different. And it deplored the fact that there are too few eccentrics around today.

A few of our readers objected to what we said, pointing out that they knew of a scientist or two who could surely be classed as an eccentric—which of course was fine with us.

As a sort of sequel to this, another U.S. editor recently said he thought the world is getting too small for stereotypes—that some of our problems today come from ideas too firmly set and minds too tightly padlocked.

We can't vouch for the outcome of getting rid of stereotypes, but we do know that opening a few padlocks to the mind can make a world of difference in one's viewpoint and understanding. As a matter of fact, we like to think that the authors who speak to us from this issue of *Review* have offered some facts and opinions not dulled by commonality.

Consider, for example, Vic Christopherson's statement that more intensive study of the aches and pains of rural people could lead to new concepts of rural development problems. Or Author Frink's cryptic comment, "Green lawns lead to green lakes." Or Dean Wittwer's bold observation that agricultural communication has made little progress in the past 50 years.

Ideas like these tend to shake us up—if we're stereotypes, that is. And if we operate true to form, we immediately search our minds to find a rebuttal or two. In effect, what we're doing is to make sure some of our padlocks are secure. Enlightenment comes, of course, when we discover there's nothing left to do but to sweep out the old idea and accord a measure of truth to the new one.

So if the world really is getting too small for stereotypes, then the agricultural sciences might be a good place to start to make room for those who have the courage to march to the rhythm of a different beat.—W.W.K.

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CONSERVATION and RURAL DEVELOPMENT in Great Britain

H. E. BRACEY

IN using the word *conservation*, one distinction that needs to be made is that the British people apply quite a different meaning to it than Americans do. With us, conservation begins with *preservation*. I've got the feeling that when the people in America hear the word *conservation*, they instinctively think of soil, plants, wild animals, pure water, and clean air. In Britain, we go further than this. In fact, many of us would begin with the conservation of old buildings, of streets, neighborhoods, and old towns. At the same time, all of us would include conservation of the countryside.

For some 100 years, there have been societies in Britain composed of enlightened men and women who have believed passionately that man was on the way to destroying a very pleasant environment that had taken us 12 centuries to create. Now, I have to remind you that virtually all the landscape in Britain—and Europe—has been modified by man. Very little of it is natural. In the United States, I suppose you are getting to this stage in some places, are you not? But you have a great deal more truly natural landscape; we have hardly none.

This interference with Nature accelerated phenomenally, as you know, during the 19th century. In Britain, agricultural land was enclosed at a frightening speed, compared with the leisurely rate over the previous 9 or 10 centuries. During the 19th century, footpaths were disappearing, open land was disappearing, common land was vanishing, and ordinary people were finding themselves shut out of land—which they didn't actually own, but to which they had had access for centuries.

These preservation societies have helped immensely to educate us in Britain and to lead us to adopt our special brand of conservation. Indeed, the fact that every county in Britain now has a county naturalist trust derives from this concern for the countryside that stemmed from the early naturalists of the last century who persuaded Parliament that bird sanctuaries were a good thing. (Perhaps I should explain what a county is in Britain; it's not the same as in America. A county in America would be called a rural district in Britain; a county in Britain is an area of about 30 by 50 miles and has a population of about half a million. It is the intermediate area of government between the central government and the village.)

In this century, the followers of these early naturalists have persuaded people that nature reserves are a good thing, that we ought to have a nature conservancy and a national trust and national

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This article was adapted from an informal talk which the author made at a staff meeting of the Cooperative State Research Service, USDA, on Mar. 8, 1971, at Washington, D. C.

parks—and finally in the last few years that we ought to have some concern for the preservation and conservation of the countryside. Because of this, we've had two very important acts in the last 3 or 4 years. One is called the Countryside Act and the other is the Civic Amenities Act; I return to these later.

What do we mean by conservation? It will be awfully difficult to give a definition for this. Care for the countryside and care for town developed first of all as preservation. In fact conservation to some extent is cursed by the word *preservation*. At the outset, the few enthusiasts working for preservation had to concentrate on preserving historical buildings, cathedrals, and things like that. Unfortunately the people concerned with preservation were kind of "other-worldly"—unpractical clerics, pensioned civic servants, retired Indian army officers. They mixed up the social life with preservation, and this gave it a rather bad name. But nevertheless they did add a lot of good, because they had the time and the money. They were intelligent people. They did see that certain parts of our country were preserved. But preservation remained an upper and middle class preoccupation up until the last war. It has been only since the last war that conservation has become the responsibility of the likes of you and me.

Since World War II, we've had a more widely distributed wealth and an increasing individual wealth with more leisure, greater mobility, better education, and more widely disseminated information through the various news media. We have built up a wider and deeper appreciation of the threat to man's environment with improvements in technology. The dilettante preservationists of the last century or the early part of this century have been replaced in many cases and augmented in others. The old guard is gradually being elbowed out by people who are vitally concerned with the preservation of wildlife and the preservation of historic buildings and historic sites and by specialists drawn from all disciplines and all walks of life, not necessarily the upper and middle classes. These new types reject preservation for its own sake and describe themselves as conservationists.

Aims of Conservationists

NOW I still realize that I haven't got around to a definition of *conservation*—that I'm just walking around it. But I had to walk around it to explain why preservation means what it does, and why it is not quite a nice word in amenity consideration.

When I tried to find a "snappy" definition for *conservation*, I failed. I came to the conclusion that a conservationist today does four or five things. First, he seeks out all the things that he wants to preserve or conserve. He lists them and identifies them and organizes them. Next, he devises plans for protecting or conserving. Third, he uses each of these resources for the purpose's best use. The old preservationists will take hold of ancient building and preserve it as a museum. The modern conservationist takes an ancient building, gets it put in order, but doesn't use it as a museum. In most cases he gets the local education authority to organize various activities associated with it and uses it or manages it. The modern conservationist recognizes that change is absolutely essential and very often beneficial. The old preservationists say we must keep this as exactly as it was. But the present day conservationists say, it is very nice as it is, but if we do something, we can improve it; we'll still keep the essential elements. This, it seems to me, is the essence of our change in thinking.

Having said this—and I perhaps have over emphasized change—I think that we have got to remember these things: that certain resources, whether a piece of countryside or a plant, animal, or building, certain resources whether natural or manmade are limited in numbers. They may be valuable intrinsically, scientifically, or socially. They may be fragile or transient. But equally, one must recognize that for conservation to succeed it must contain an element of management to get efficiency of use and continuity of supply. Perhaps even more than that, you must convince the people that they've got to pay the piper if the job is worth doing. This, it seems to me, is one of the essentials of conservation, one of the difficulties of conservation. So rather than giving you a definition of conservation, I think I can give you four words that summarize what we feel about conservation.

First of all, there must be *recognition,* because the average person can't always recognize the things that need conserving or preserving. This is your job —the specialist's job. Second is *preservation.* Third —and this is where we part from the preservationists—is *change.* And the fourth is *management*—to see that you get things done properly.

I have introduced a new word here—*change.* Change has been with us since the beginning of time, but today it is the staggering rate of change which is often fearful or challenging. This rate of change emphasizes the urgency for action. At the same time, we have to recognize that individual action can often be the worst possible thing, and it is therefore not independent, isolated action that we want but concerted, well-informed action. This is what European Conservation Year has been all about.

Conservation vs. Pollution

I may be wrong on this, but I think what we mean and how we apply conservation in Europe is a little different from the way in which you understand or explain conservation in the United States. I have the feeling that the word *pollution* covers a great deal of the thinking about conservation in the United States—not among you agriculturists, of course, but among the rest of your population. Pollution of the environment, whether of the land, sea, or air—this is one of your moving factors of the moment. Pollution, to me, suggests control, and this is negative. Conservation, to me, suggests action, and this is positive. I myself would soft peddle the pollution because you've got to do something negative about it to stop it. Instead, I would emphasize conservation because it means you've got to do something positive.

Adaptation of the Environment

I must emphasize again that, compared with the United States, Britain's countryside is much more artificial, much more unnatural—it's manmade; it was once forest and scrubs. The present landscape has evolved, and I use the word *evolve,* because I want to emphasize the relative slowness of the rate of change which we have had over the centuries. This slow rate of change permitted adaptation—permitted nature to adapt, permitted man to adapt and allowed us to live reasonably comfortably in the last 10 centuries. But Nature's adaptation to man, you must remember, is superficial and transitory. Left to itself or under certain conditions if badly used by man, improved agricultural land returns again to scrub and waste or even worse. Now this retrogression of improved landscape can, of course, be hastened by man's carelessness—carelessness in the disposal of industrial wastes, or unwise use of modern processes associated with technology, or in agriculture, the use of toxic chemicals. Or—and this is one thing we're particularly concerned about in Britain—it can be the unthinking trampling of too many human feet over tiny plant or animal organisms.

Traffic

FOR the sake of making my picture whole, I must mention traffic. Of all the changes brought about during the last decade in the environment in town and country in Britain and over the last two decades in the United States, one of the greatest is the staggering number and size of road vehicles of all types. At the moment, there are 11 million cars on the roads of the United Kingdom and by the year 2000 there will be 28 million. This may not mean much to you, but remember that the area of Britain is about the area of Pennsylvania. Pennsylvania has about 11 million people; we have 50 million, and by the year 2000 we're due to have 68 million. And having 68 million people in an area

about the size of Pennsylvania, along with 28 million cars, you can imagine our sort of problem and the intensity of our fears.

Active Leisure

IN the last 5 to 10 years there has been an enormous increase in active leisure in Britain. And much of the increased traffic on the roads is related to the transformation which the private motorcar ownership has brought in the pattern of active leisure. In the United States and in the countries of Western Europe, it is clear from surveys that as income rises and leisure increases, participation in active pursuits develops. In Britain we can show dramatic increases in membership in organizations like the camping clubs, the caravan clubs, and outdoor activity clubs of all kinds.

But besides this interest in active pursuits, the number of people interested in less active pursuits is increasing in Britain as we put people on wheels. They visit ancient properties and monuments. Membership in bird watching clubs is just billowing out, the amateur naturalists are increasing, and there is growing awareness of the natural and pleasant manmade environments—an awareness by ordinary people.

Focusing attention on the general environment, I think our problems are a little different because in Britain our landscape is of a smaller scale. We have no massive mountains like your Western mountains, nor massive plains areas like your Middle West. Its small scale is presumably what makes it attractive to us. We have smaller plains, smaller villages, smaller rivers and twisted roads. This means that we have enormous variety over very short distances. (One of the greatest shocks of my life came when I spent 5 days in driving from Cornell to the Rockies. It was quite traumatic.) These present features of our landscape have drawn Americans to our shores in increasing numbers. In recent years they have been joined by more and more visitors from European countries, and we now welcome some 7 million tourists to Britain annually.

The mass of British people have discovered these new delights of the countryside only recently. In the past, the Mecca of most holiday-makers in Britain was a static holiday at the seaside. You have nothing in this country—as far as I know—like the British seaside. There are towns along the coast—towns up to 20,000 or 30,000 people or more—geared to accept 100,000 people every July and August, providing bed, board, and amusements of all kinds for all ages. This was all right as long as we didn't have so many people. But now we are running out of coastline and the congestion behind the coast and inland is quite unacceptable. We recognize that the countryside is at risk.

Concern for the Countryside

A new interest in the countryside shows itself in a great variety of sports of all kinds—ordinary family outings, increasing education-type excursions, all kinds of groups organizing activities that get people out and learn about the countryside; and finally, there is the ordinary weekend and holiday family excursion. This means that the countryside is at risk from vandalism in a way that it has never been before—vandalism of all types whether it is leaving open the farmer's gate or breaking it down. This is an economic expense as well as destroying the appearance of the countryside. We believe that a lot of the vandalism taking place in Britain is due to carelessness and ignorance, and we feel that we've got to do something about it.

Having said this, I'm beginning to wonder if you really understand what I mean when I say the *countryside* is at risk. I've got the feeling that you and I don't mean quite the same thing by the word *countryside*. Because of our enormous variety of countryside, it means something rather special to us. If you travel all day through corn or cotton, it is cornland or cottonland—not countryside.

When *you* go out into the countryside, you've got Federal parks and State parks, which I think are wonderful. It was a marvelous idea to have developed them in the first place, and today they serve as the "honey pots" to which you can get your motorists when they are out having fun.

But what can we in Britain do? Picnic on the roadside and swallow the dust from the trucks? There is not much else that the average family knows how to do. This is one of our problems. We've got to provide areas, as you have done, where people can find the real countryside and not ruin it, because along any of our main roads to the coast during August, every little lay-by (turn out) is cluttered with paper where people are fouling up the countryside.

You see, for 30 or 40 years, 90 percent of the population of Britain has been urban. I know you are getting to that stage in some parts of your country too, but we've been at it for a longer time. Our fathers and grandfathers were urban dwellers also, which means that 90 percent of our population doesn't know what the countryside is or what it's for. But if I took a count here, I'm sure I would find that 90 percent of *your* fathers were born on a farm.

You will have sensed my fear of harm coming to the countryside through more people using more of the countryside for more purposes and more of the time. Conservation, for me, means (1) controlling those people, (2) managing the countryside, and (3) managing it in such a fashion that the majority of us in Britain accept it and accept it before it is too late.

It has taken us 10 to 12 centuries to create our attractive countryside and we want to keep it like that. We could destroy it in 10 years, and this is not an exaggeration. We realize that we can't stop the cars coming out; you've tried and failed. We can't let people park their cars where they like and picnic on the side of the road and play dangerous games. We are having to follow you and provide honey pots, provide parks like you have.

This is not so simple as it sounds. It was much easier for you to draw the Yellowstone area on the map some 50 to 80 years ago, because there was no one living there—or no one you considered important, anyway. By contrast, every inch of land in Britain—virtually throughout Europe too—belongs to somebody for some purpose. So if you want to start a national park, you have to get rid of that fellow or get rid of his job. This is our problem. You have to go very slowly, because when you put out legislation to persuade a local planning authority to prepare a countryside park you've got to provide them with money to buy out rights or buy out land. You've got to educate people that plants and places need protection. But when you encourage thousands of people to go into a small area, you know what happens. So you've got to prepare the people as well as protect the plants. Our problem is we've got to give all kinds of education to all kinds of people about all kinds of things, all at once.

If only we could get more of my people to your country to tour your national parks and State parks, I'm sure we could get the job done more easily. Your State and national parks are, as a whole, absolutely magnificent—especially the way in which you tie in your education. You link education with civic development and responsibility, and you get people interested in biology or economics. This has obviously been developing over many years, and its excellence has been due to the experience of many years. This is what we have to do in Britain sometime, but it's not easy to achieve when you have to buy or rent every square inch of land and train so many people so quickly.

I said earlier that we should control the cars. This is a difficult thing to do and nobody knows this better than you. We appear quite unable to control their numbers especially during the summer and weekends. The position is worsened in Britain because of the crooked British roads. This is not because we are too lazy to straighten them out. They have developed over 10 centuries for particular purposes. They aren't controlled, like your roads, by relief or the fact that there's one place here and another place there. In early Saxon times when fields were enclosed, you didn't go through a chap's field, you went around it. This was the way we began our road systems.

Opposition to Change

APART from this, sometimes there seems to be opposition from every rural individual to change of any kind. This is common experience throughout Europe and Britain. The organization of opposition must beat that of any other country in the world. Against the most magnificent opposition, we are at last trying to develop a system of motor roads. Let me illustrate the way opposition gets to work. You have a twisted road outside a little town. First of all, the county highway authority announces that it is going to straighten it. The plans are published, and the Minister of Transport is informed because a government grant-in-aid will be expected. Then the village tradesmen may say that straightening out the road is going to cut them off from passing trade, so they organize a petition to the county council. Next the local naturalists come in and they discover that the drainage associated with the new course of the road will cause the disappearance of a rare bog and a rare bog plant. They persuade their national organization to organize a national petition to the Minister of the Environment. I'm not exaggerating; field, you went around it. This was the way we be-

Rightly so, if you are a biologist or a naturalist, you have to shout or the officials will walk right over you all the time.

The archaeologists have been having a field day lately. As more and more massive pieces of earth-moving equipment have been employed on road building, they have been turning up all kinds of things the Romans and Saxons left behind and even the ancient Britains before the Romans. Not a week passes by without a new find turning up. Not so long ago, no self-respecting archaeologist would have allowed himself to be associated with any digs or remains after the time of Queen Elizabeth—the 1600's. Now, however, a new breed who call themselves industrial archaeologists rush into ecstacy over items of the last century. You can bet your last dollar that some part of any new road is going to pass through an area potentially rich in archaeological history. And if you are against progress locally, you can also bet that you can get at least one local group of archaeologists to support you.

Then there is the Council for the Protection of Rural England—it used to be Preservation, but they've changed it—a very respectable national society with a great number of civic societies and other bodies affiliated with it. This council can be expected to come to the local aid of any proposed development which in the opinions of its members is likely to harm the countryside. Harm means the removal of trees—they are sacred objects. Harm means introducing any feature alien to the landscape, such as a new road or a straight road. Harm means the removal of certain buildings which the owners have allowed to become derelict, but which acquire immense historical and architectural significance once they are threatened by demolition.

I haven't as yet mentioned the local parish council or the district council for the National Farmers Union or civic society or the women's institutes and I could go on like this.

Then there are the planners. Any kind of development in a house or road or change in use of premises is subject to the owner or operator obtaining planning permission. If you change any thing

at all, you have to get permission. Proposals must be published, and if there are sufficient objections, the Minister of the central government who is responsible for planning will send down someone to preside over the inquiry. Even if the evidence is against the development, the Minister may order the work to proceed if he deems it be in the national interest. Normally, the decision of the inspector is followed, but it can be reversed by the Minister.

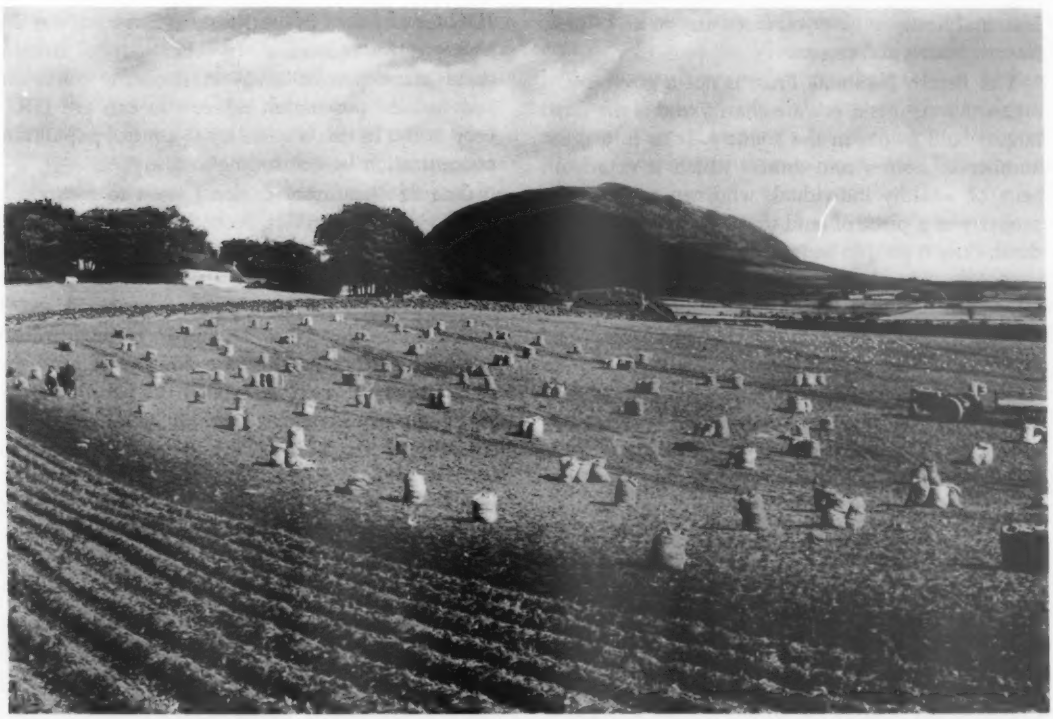
Finally, the British countryside is something special, and there are a great number of people and organizations who are prepared to go to great lengths including making fools of themselves, and spend a great deal of money to prevent what they regard as harmful or unwise development.

One thing I've heard a lot about in my country—and I don't think I ever heard it or read about it in American publications—is preserving the countryside for posterity. In Britain, we believe that the countryside is very special, and we've got to look after it and protect it as you would look after a weak and ailing child. This is quite genuinely felt not only by countrymen but by townsmen who probably see it only two or three times a year. It is probably being developed through reading and the news media or university lectures or educational programs and that sort of thing.

I may have strayed from my subject somewhat, but I think it was necessary because a major question we have to answer in Britain—we haven't answered it yet, but we think we are on the way to do it—is how to preserve the seemliness of the countryside.

Statutory Aids

NOW I want to say a word about the statutory aids to conservation. We do have national parks—10 of them. Within them, there are areas of high landscape value, with a potential development for a particular social purpose or recreation. But unlike your parks, all the land is in private ownership. Some of them have industrial developments; sometimes urban development exists. We can't avoid



Potato harvesting in County Antrim, Northern Ireland. (Courtesy: *British Travel Association.*)

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this; it was there before the parks.

If you go to Britain, you may be lucky enough to drive through the Snowdonian National Park or the Dartmoor National Park—two highland areas which are enclosed by lines on the map and are designated as national parks. But you will find few of the provisions for fun and games that you have in yours—and very little provision for disseminating information. The important thing about these 10 national parks is that they represent areas of high landscape value and each park has its own planning authority; anyone who puts up a proposal for development that is not in keeping with the locality will have quite a rough time of it. As time goes on, we are providing money for more and more car parks, reception areas, sanitary facilities and so on. These areas attract 60 to 80 percent grants from the government for approved programs of development. In this way, the central government is, in fact, stimulating the development of national parks.

Another statutory aid is the National Trust. When you are in Britain anytime with your own car and free to wander, you can buy a membership of the National Trust to give you free entry to all of their historic homes and estates.

The British National Trust is not a government organization; it is a private charity and is the third largest land owner in the country. It owns a great number of houses and estates which it gets from heirs of wealthy individuals who can turn over a property or a piece of land to the government when death duty is paid in lieu of taxes. Although they do lose ownership of the property, in many cases the original owners are allowed to continue to live in it, as long as they keep the property open for access to the public for about two-thirds of the year. The National Trust also owns nature reserves, historical properties, and, in some cases, whole villages. Recently the Trust conducted an "Operation Neptune" drive from which they got a couple of million pounds by subscription for purchasing coastal land. The National Trust land is open to anybody as in the same way that you can wander around in your national parks. You pay only when you go into the actual buildings.

Another statutory device is a "special area". Every county council, that is, which is the planning authority, has to mark on its county plan map every special area in a green color. Once so marked and labeled, no development is allowed which might remotely be considered to be harmful to the locality, scientifically or aesthetically.

Other areas of special interest include Areas of Outstanding Natural Beauty. This may be whole hillsides—extending 20 miles or so—similar to your national park areas, but still in private ownership. There are also Areas of Special Scientific Value and nature reserves and Forestry Commission lands. Other specially protected areas include "green belts," long-distance footpaths, land which has been common land for ages, buildings, or groups of buildings which have been specified as conservation areas.

Another statutory device is the control of industrial and commercial development. To illustrate, southeastern Britain—a very small part of our country—has more than one-fourth of our population. One way to stop any further growth of this highly concentrated development is to forbid any industrial development on new sites in that area. We can't forbid it completely, of course, so what we do is to require the developer to get an IDC, an Industrial Development Certificate. If you can get an IDC for any area in southeastern England, you are a very clever individual. In other parts of Britain, there are depressed areas of declining industrial activity and population where you can get IDC's very easily. In this way we try to control population concentration by controlling industry.

One final statutory device I want to mention is the Civic Amenities Act, recently enacted by Parliament. It's a sort of "tidying-up" act, designed to tidy up the countryside—eliminate litter, and that sort of thing. This is one of your problems too, I notice. Like you, we sometimes have refrigerators or washing machines that we don't want, and the people in my country developed the habit of dropping them off the back of the car some dark night. As a result, the open spaces were getting cluttered up. The Civic Amenities Act tackled this by ordering every local authority—the rural district council and the urban district council—by a certain date—I think it was within about 6 months—to make available a public dumping area for the disposal of these unwanted items and to collect those which had already been dumped in the wrong places. This procedure has worked very well. As for all the old cars that people have forgot to take home with them when they didn't want them—what we do now is

to stick a label on them ordering the owner to remove it within 7 days; if this produces no effect, they are collected by the local council and sold or junked for scrap metal use. This, too, has worked. All the derelict cars disappeared overnight almost. This aspect of the Civic Amenities Act has been very useful. It still hasn't got rid of the paper litter, but this is a matter for education.

Another section of the Civic Amenities Act increased the powers of the planning authorities so that whole areas, or streets—rather than just a single building—could be designated as being of historic value. To help you appreciate the full significance of this change, I should explain that the authority as part of normal planning procedure, draws up a list of all the buildings considered worth preserving because of their special historic value. Owners of buildings approved by the Ministry can get grants from the central government for the extra cost of maintaining the buildings. This is all right for individual buildings, but what happens when you have a group of three or four buildings next door that weren't considered worth scheduling? These deteriorate and the preserved one remains beautiful while the rest look horrible.

The Civic Amenities Act changed this by permitting the scheduling of whole streets rather than just individual buildings, in other words, "conservation areas."

Incidentally, since I retired, I have acquired the chairmanship of a civic society in my town. It is a Victorian town, very well developed in some places, but very little of the Victorian architecture is really magnificent. Now, we've got the problem of persuading the local authority that it *is* magnificent, and we're going to need a lot of energy to convince them. We hope in time to do it, and I'm sure we shall.

* * *

In conclusion, may I return to where I set out—the countryside. We in Britain know we've got a beautiful countryside and we are proud of it. We acquired it mainly by accident through economic use and the type of land ownership. We now have reached the stage where we can't keep it by accident; we've got to do something positive about it. The pressures on our countryside are infinitely greater than on yours, except in certain areas. We've got to direct the wheels somehow, and we've got to direct people. We've got to control them, but we can't control them solely by forbidding. We must provide alternatives, and this means that we're going to need greater community action, more effective control and development, and, of course, to spend more money. It really means that we've got to stick our nose further in the "noose" of being planned.

SCIENCE NOTES

WHY GROW FRUIT ON TREES?

AFTER 4 years of research on a revolutionary new fruit-raising system, J. P. Hudson of the Long Ashton Research Station, University of Bristol, seriously poses the question in the above title.

Called the "meadow orchard" system, it is a plan for growing fruit on 2-year old shoots, harvesting it mechanically by mowing off the orchard with some form of combine harvester which would separate the fruit and shred the shoots back on the ground. In the following year a single shoot would be allowed to grow from the stump to repeat the process of cropping 2 years later.

In small-lot testing with Orange Pippin apples, 2-year old shoots bore an average of 4 pounds of high quality fruit per tree without any chemical treatment. Stumps of this variety are now in their third cycle and doing nicely.

Bishop believes the system deserves a concerted attack by scientists as a possible means of overcoming the disadvantages of traditional fruit growing, particularly the high labor costs.—*Agriculture, 78:4, 1971*

One acre of growing forest produces about 4 tons of oxygen a year—enough for 18 people a year.

Plant pathologists estimate that the spores of Southern corn leaf blight—about the same size as ragweed pollen grains—can be blown 200 miles or more over land without losing their viability.

MEDICAL GENETICS

Current progress in medical genetics is dramatic enough to be compared with the medical revolution of the last half of the 19th century that followed the establishment of the germ theory of disease. After years of basic accomplishments, the impact of genetics in medical practice is just beginning to be felt. This impact is bound to be a major-one—not because the incidence of genetic diseases is increasing, but because the decline of infectious diseases has brought genetic diseases into new prominence.

Infant mortality from congenital malformations is roughly the same as in 1900—about 5 per 1,000 live births. In 1900, however, the total infant mortality was 150 per 1,000 live births compared with 20 per 1,000 in 1970.

Although the incidence of congenital abnormalities has remained constant, these causes of death now account for about 25 percent of all infant mortality compared with only 4 percent in 1900. The incidence of congenital defects has not changed appreciably, but vaccines, antibiotics, and sanitation have decreased infectious diseases and the relative importance of genetic diseases has increased—*Utah Science, 31:4*

Tests with chickens by the Canadian National Research Council show promise that a microwave beam of appropriate frequency and intensity could provide a "bird-free" corridor for safe landing and take-off of airplanes at airports—without harm to the birds.

Plant Nutrients and Water Quality

C. R. FRINK

THE symptoms of eutrophication are well known by now, but the causes are still the subject of controversy. Rather than quibble over various limiting nutrient theories or water quality standards, I suggest we consider that any increase in plant nutrients in waterways may increase the growth of weeds and algae.

By examining nutrient inputs and outputs for a given ecosystem, thereby deriving a nutrient budget, we can frequently determine if nutrients are lost to waterways. Hence, I have analyzed various nutrient budgets, first for the United States and then for watersheds, farming systems, and political subdivisions.

The results reveal a number of ways to minimize nutrient losses based on present knowledge and also suggest profitable avenues for further research.

NATIONAL NUTRIENT BUDGETS

Fertilizers as Nutrient Sources

AGRICULTURAL spokesmen have voiced such divergent views on the contribution of fertilizers to nutrient pollution that it seems impossible that we are talking about the same subject. I know that my view of U.S. agriculture from Connecticut is certainly myopic. Others may not suffer to the same degree, but I submit that many of us are guilty of extrapolating findings from our scientific backyards across 3,000 miles of widely different soil types, management practices, and climates.

Accordingly, I looked again at the United States, this time armed with a general soils map, some precipitation, runoff and temperature overlays, (*33*)[1]

[1] Italic numbers in parentheses refer to Literature Cited, p. 24.

and maps, of management practices from the 1957 Yearbook of Agriculture (*2*). Although this seems an elementary approach, I found it quite useful in my attempts to examine agricultural contributions to nutrient pollution.

To simplify this discussion, I combined 16 great soil groups (*33*) into three broad categories in figure 1: (a) Soils 1–5, generally highly leached and consequently low in native fertility; (b) soils 6–12, subject to less leaching, with higher organic matter contents, and hence higher native fertility; and (c) soils 13–16, receiving much less rain, with little runoff, and generally low in fertility.

Comparison with figure 2 shows that the lines of equal runoff delineate the soil boundaries from east to west reasonably well, while the isotherms of mean annual air temperatures of 45° and 60° separate the soils of higher organic content in the northern States from the weathered, less fertile soils in southern regions. Detailed management practices maps indicate that most farmers have chosen not to fight their environment but have adapted their practices to the soils and climate of the region where they farm (*2*).

With this simplified grouping of soils and management practices, I would like first to examine agricultural contributions to nutrient pollution in the United States on a regional basis. Later, we may need to examine various soil types, management practices, and climatic differences but this can lead us back to the provincialism I hoped to avoid.

One other simplification that needs to be clearly stated is the different pathways that nutrients are assumed to follow through the environment. Since nitrate nitrogen is soluble in water, it is assumed to move downward in solution through soil profiles to ground water unless removed by a growing crop or lost by denitrification. Phosphorus, however, is assumed to be retained by soils and move largely to surface water supplies as the result of erosion. Other nutrients are frequently implicated as causing eutrophication, carbon dioxide achieving notoriety at the moment (*17*). However, nitrogen and phosphorus are surely major factors in eutrophication (*20*) and I shall confine my remarks to these two nutrients.

Continuing with this analysis, agriculture in soil region 1–5 (the humid East and some areas in the West, figure 1) is generally on a "put and take" basis: what you take off in crops you must put on in fertilizer. Excess nitrogen applied to bare or frozen soil and not utilized by the crop will likely end up in ground water or be lost to the atmosphere by denitrification. Analysis of agricultural operations by nutrient budgets (*11*) in this region should provide reasonable estimates of the losses of nutrients, particularly nitrogen, to ground water. Within this region, native soil fertility is somewhat higher in the northern States, decreasing as soil temperatures increase in the southern States. Potential runoff is quite high on the East Coast, decreasing to about 10 inches as we proceed west, and increasing again in the Pacific Northwest. Soil erosion is severe in the southern part of the region, soil 4, where intensive cropping and high runoff combine to promote losses of soil phosphorus.

Moving westward to the prairies and plains, soil region 6–12, we enter an area where residual fertility is high and farmers are still mining native soil nitrogen. Nutrient budget calculations applied in this region frequently overlook this elementary fact. The absurd conclusion is then drawn that since more nutrients are removed in crops than are applied in fertilizer, agriculture cannot possibly be polluting the environment. One further step in this absurdity has been to extend these calculations to a national average nutrient budget which clearly shows agricultural fertilizer to be blameless. Another consequence of this high native fertility, which decreases somewhat from north to south, is that soils will deliver nitrate to ground water even in the absence of added fertilizer. Potential runoff is much less than in the eastern United States, decreasing to 1 inch or less at the western boundary of this region. Erosion, however, is severe in soil regions 7 and 9, providing a high potential yield of phosphorus to waterways.

A special category of intensive use of these soils in the western States involves irrigation, as in California, where a part of the ground water is cycled through a soil-crop filter and back to ground water again. Under these conditions, nitrate concentrations tend to increase, along with other salts, and high concentrations are frequently observed. However, reasonable estimates of the nitrogen added to ground water have been obtained from nutrient budgets (*30*). In this region, soil 10 has been grouped for convenience with the high fertility soils; however, significant differences in fertility do exist. Surface erosion is also of consequence in the high

runoff areas of this region.

The third soil region, 13–16, in the arid to semi-arid West is not an area of intensive agriculture, since only a small amount of water is available for irrigation. Here again, however, we should be able to derive reasonably useful nutrient budgets where agriculture exists.

While some may disagree with the boundaries I have drawn, I think it evident that we have three widely different regions in the United States which cannot reasonably be combined in calculating the "average" agricultural contribution to nutrient accumulation in waterways. Moreover, findings in one area do not necessarily apply in others. Although we may view with alarm the increased concentrations of nitrate observed in ground water in closed irrigation systems in the West, they are not as likely to occur in the humid East where greater volumes of water wash through the soil to the sea. Under eastern conditions, although nitrate concentrations in ground water can certainly be increased by agricultural operations, the increase is not as likely to be irreversible. In the Midwest, fertile soils may deliver nitrate to a crop or to ground water in the absence of added fertilizer. Finally, soil conservation is frequently said to be the cure-all for agricultural pollution, but this conclusion also needs examination. Such practices will indeed reduce losses of phosphorus from erosion-susceptible areas of the South and Midwest, but will have little effect in other parts of the country. Losses of soil nitrogen are not nearly as susceptible to control by soil conservation since nitrate moves through the soil rather than with it.

Other Nutrient Sources

To evaluate the contributions of fertilizers to nutrient pollution, we must examine all other nutrient sources in the environment as well. Thus, super-

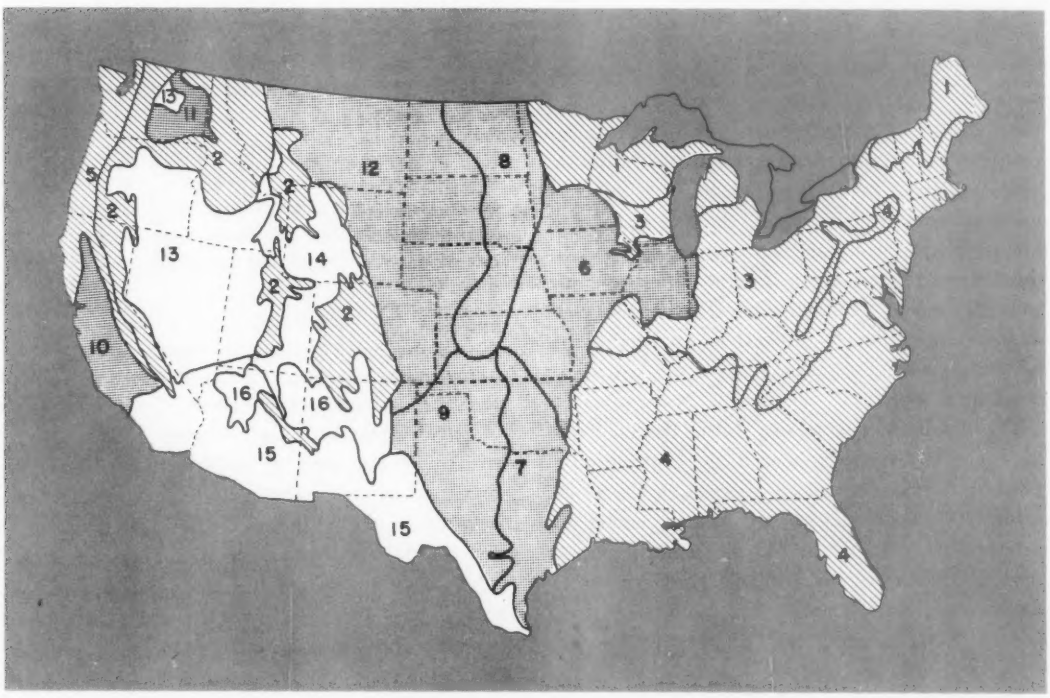

Figure 1.—Generalized soils map of the United States. Soils 1–5 are generally highly leached and low in native fertility, while soils 6–12 are subject to less leaching and are high in native fertility. Soils 13–16 receive little water and are generally infertile.

imposed on this distribution of soils and climates, with consequent different fertilizer use patterns, are two other major sources of nutrients: animals and man. Being mobile, they do not lend themselves to neat mapping units as do soils. Moreover, the nutrients in their wastes are largely derived from fertilizers and soils, so that these sources are not completely additive. Again, however, we can make some generalizations. Animals tend to be integral parts of cropping systems in the East, so that manure is returned to the fields that feed the animals. Under these conditions, it is difficult and, fortunately, needless for budgeting to distinguish nutrients in manure from those in fertilizer (*11*).

In the Midwest, where large feedlots are common, manure tends to accumulate to considerable depths. Although the pollution potential from such practices appears extremely high, recent evidence (*23*) indicates that this may not be as serious as anticipated. First, runoff is slight and net downward movement of dissolved nutrients is small. Second, reducing conditions prevail under the manure pack, and hence considerable nitrogen is lost by denitrification. Thus, present evidence suggests that perhaps the manure is best left to decay anaerobically in the feedlot, rather than spread on fields as deeply as dictated by the limited acreage available.

In arid areas, manure often accumulates in immense piles since crop land is not available and the limited rainfall makes leaching of little concern. Rates of decomposition under these circumstances are probably slow. Clearly, animal waste disposal in these three regions presents three different problems. Moreover, although some soil scientists tend to view animal waste disposal as an engineering problem, I believe wastes applied to soils are a soils problem as well.

The distribution of people in the United States is in general inversely related to the distribution of animals. Methods of waste disposal, however, are similar. Where few people are located, wastes are generally returned to the soil via septic tanks. As people gather in cities, available land disappears, sewage treatment plants are built, and large quantities of both nitrogen and phosphorus are discharged directly to lakes and streams.

The remaining source of nitrogen is the atmosphere, with inputs in rainfall and biological nitrogen fixation, accompanied by losses due to denitrification and volatilization. A recent attempt to establish a global nitrogen cycle (*28*) reveals significant gaps in our knowledge of the complex reactions of nitrogen in the environment. Soil scientists have struggled with nitrogen balance sheets for many years, but biological gains and losses are still an enigma (*1*). Although some feel that our ignorance of these reactions precludes any definitive statements regarding losses of nitrogen to ground water, the urgency of the problem requires that we make the best possible use of what we do know, rather than bemoaning our ignorance.

REGIONAL NUTRIENT BUDGETS

HAVING shown that the "average" contribution of plant nutrients from man's various activities is not a very useful concept when applied to the Nation as a whole, we might ask what the most logical subdivisions would be. The three regions of the United States discussed above are a start, but they are still rather heterogeneous and encompass a variety of nutrient sources that are difficult to describe quantitatively.

Watersheds might be a logical choice, since our primary concern is the effect of our practices on water quality. Because of the diversity of land use in many large watersheds, direct measurements are usually considered necessary, but these are expensive and require collection of data over long periods of time. Calibrated watersheds have the advantage that once instrumented, results from indirect methods of nutrient budgeting can be verified. In addition, land use patterns in the watershed can be changed and various experimental methods of reducing nutrient yields can be tested. Farming operations might be a better category, particularly suited to systems analysis, where results from many years of experimentation should enable us to arrive at reasonable estimates of nutrient losses. This approach, however, requires estimates of nutrients from other sources in order that losses from farms be placed in proper perspective. Finally, political subdivisions are where the action is: decisions to treat domestic sewage, regulate manure disposal, or tax farm fertilizer are usually made along political rather than ecological boundaries.

In all likelihood, scientists may well be asked to estimate nutrient yields and their effects on water quality in all three of these categories: watersheds,

farming systems, and political units. Hence, I would like to review some of the attempts that have been made to analyze these three systems.

Watersheds

PERHAPS the simplest calibrated watersheds are the well-known lysimeters installed at several agricultural experiment stations shortly after the turn of the century. Although lysimeters are artificial systems, usually with disturbed soils, they do illustrate the large losses of nitrogen that may occur in the absence of a crop. Allison (*1*) has reviewed most of the lysimeter studies in this country, and in addition has evaluated findings from numerous experiments with N^{15}-tagged fertilizers. He states:

"Only rarely have . . . tests shown nitrogen recoveries in the crop plus soil greater than about 95 percent of the applied nitrogen; values of only 70 to 90 percent are fairly common, and a few are as low as 60 percent.

"Such results, obtained under ideal conditions where no leaching occurred, help to explain why nitrogen recoveries in the crop under average field conditions often are no greater than 50 to 60 percent of that applied, even if immobilization is taken into account." Allison further notes that the most probable cause of this loss is leaching during fall and spring.

Thus, although we may not expect to extrapolate these findings directly to the field, we should not be surprised if large losses of nitrogen are observed under some conditions. Unfortunately, most lysimeter experiments dealt only with nitrogen, and phosphorus losses are reported merely as a "trace". However, as Viets (*32*) has noted, we must appreciate the difference in magnitude between the amounts of nutrients applied and the small losses that may cause eutrophication: in the case of phosphorus, for example, the loss of 1 percent of a

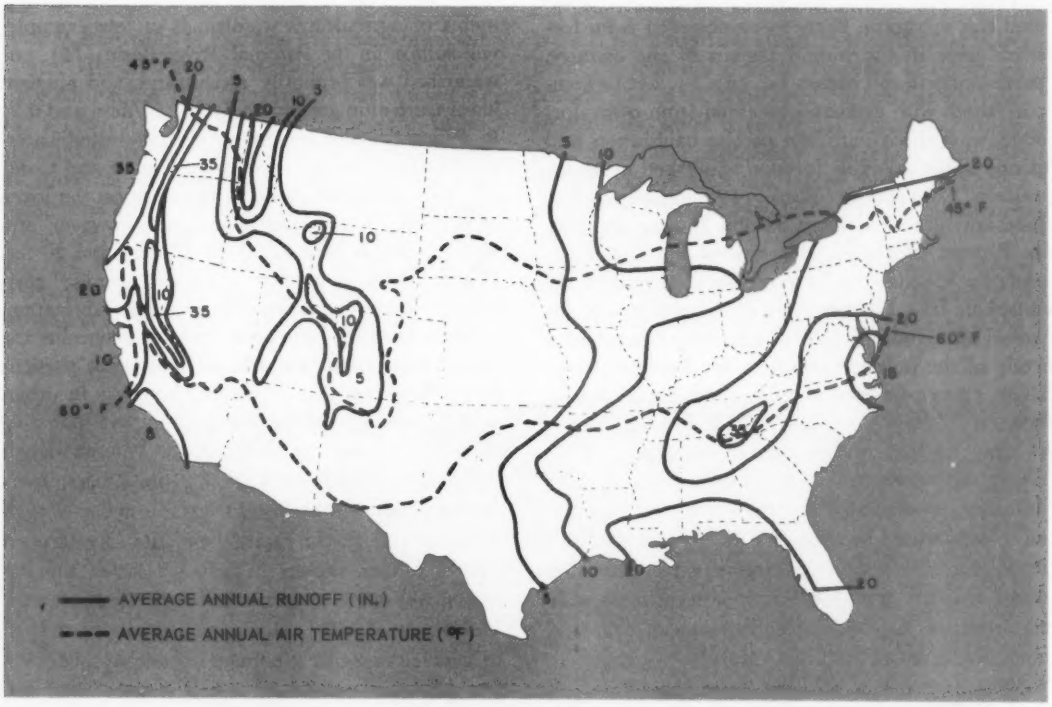

FIGURE 2.—Generalized climatological map of the United States. Comparison with figure 1 shows that the lines of equal runoff approximate the soil boundaries from east to west, while the isotherms separate the soils of higher organic content in the northern States from the weathered soils in southern regions.

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modest application of 40 lbs. of P_2O_5 per acre is enough to eutrophy 5 acre-feet of water or its equivalent of 60 inches of runoff. Thus, a "trace" takes on more importance.

Although a number of calibrated watersheds are under construction by the USDA and by TVA, few experimental data are yet available. One watershed in New Hampshire, however, has provided valuable information on nutrient losses from forested areas unaffected by man's activities. Bormann, *et al.* (*4*), reported that annual losses of nitrogen from an undisturbed beech-maple-birch forest amounted to about 1.6 lbs. N/acre. Inputs in precipitation exceeded outputs in stream water, for a mean net annual gain over a 2-year period of about 3.3 lbs. N/acre. Thus, even the forest was not using nitrogen very efficiently; an average recovery of nitrogen inputs was only 68 percent. Losses of phosphorus from the system were not measured initially; however, recent data (Likens, private communication) indicate that losses amount to about 0.02 lb. P/acre.

Thus, these losses of nutrients might be considered the minimum likely to be observed from forested areas in the humid regions of the country, particularly in soil region 1–5 (fig. 1). Let us compare them with estimates obtained from other forested watersheds with less precise calibration and sampling. In a largely forested watershed in northwestern Connecticut, Frink (*10*) estimated that losses amounted to about 3.0 lbs. N/acre and 0.21 lb. P/acre. Moreover, this modest input was apparently adequate to have produced a moderately eutrophic lake. Further south in soil region 1–5, Jaworski and Hetling (*16*) have recently completed a study of the nutrient inputs to the Potomac River Basin. From a forested watershed they found annual losses of 1.4 lbs. N/acre and 0.09 lb. P/acre. Cooper (*6*) reports some measurements in northern Minnesota during August to November, 1966. If these data are representative for the entire year, the annual losses would be about 3.1 lbs. N/acre and 0.12 lb. P/acre. Few other measurements from forested watersheds are available, but these seem reasonably consistent in view of the wide range of soils and climate (fig. 2).

Measurements of nutrient losses from "agricultural" watersheds reveal no such consistency. The 50 to 60 percent recovery of N in field experiments (*1*), and the disparity in fertilizer rates between horticultural crops and pasture lead us to expect large variability in observed losses of nitrogen. Moreover, disagreement exists over whether soluble or total amounts of nutrients should be measured. Sampling and analytical difficulties, coupled with uncertainties in measurements of runoff and percolation to ground water led me (*11*) to suggest that contributions from agricultural could best be assessed by analysis of farming systems. However, some representative data are given to show what may be expected as forests give way to farms or vice versa.

First, when trees are cut, we can expect a large increase in nutrient losses. Bormann, *et al.* (*4*), observed that when a watershed was cut over and regrowth inhibited with an herbicide, losses of nitrogen increased to nearly 50 lbs. N/acre compared with the loss of 1.6 lbs. N/acre from the undisturbed control. Losses of phosphorus increased 10-fold to about 0.2 lb./acre (Likens, private communication). These losses would surely cause accelerated eutrophication as early settlers struggled to feed themselves.

To show the extremes encountered in measurements of agricultural watersheds, a few examples will suffice. In the Potomac River Basin (*16*), one watershed was primarily agricultural, and nutrient losses were estimated to be 3.8 lbs. N/acre and 0.24 lb. P/acre, modest increases over the forested watershed included in the same study. Biggar and Corey (*3*) have reviewed much of the work on the losses of nutrients in agricultural drainage, however, and report losses as high as 50 lbs. N/acre and 20 lbs. P/acre. Thus, we discover again an "average" agricultural watershed is probably a useless frabrication.

Some attempts have been made to determine the runoff from urban watersheds. This seems particulary difficult because of varying land use in urban areas. Jaworski and Hetling (*16*) report that runoff from an urban watershed in the Potomac River Basin was 2.1 lbs. N/acre and 0.21 lb. P/acre, intermediate between the losses from forested and agricultural watersheds. From their data, I estimated the population density in urban areas of the Potomac watershed to be about 6.4 persons per acre. Weibel, *et al.* (*34*), studied an urban watershed in Cincinnati, with a population density of 9 persons per acre, and found runoff losses of 11.5 lbs. N/acre and 1.13 lbs. P/acre. Thus, urban runoff, like agricultural, appears quite variable.

In summary, runoff from forested watersheds is

TABLE 1.—*Estimates of sources of plant nutrients entering the Potomac River estuary*

Source	N	P
	Percent	
Agricultural runoff	31	8
Forest runoff	16	4
Urban runoff	2	1
Wastewater discharge	51	87

evidently reasonably uniform in soil region 1–5. However, runoff from agricultural watersheds is as varied as agriculture itself, and may range from insignificant to a major source of plant nutrients. Urban runoff has been measured in only a few watersheds and does not appear likely to be constant.

Although watersheds are variable and monitoring every watershed in the country is obviously impractical, it is useful to examine the results obtained to date. The estimates of various sources of nutrients entering the Potomac estuary are shown in table 1 (*16*). Agricultural runoff appears to be an important source of nitrogen but supplies insignificant amounts of phosphorus, which confirms our assumptions about the movement of nitrogen and phosphorus from soils. Jaworski and Hetling (*16*) compared these findings with an earlier study of the Hudson River and concluded that "for large river basins in the Middle Atlantic region, the major source of nutrients is wastewater discharges." Thus, this study reveals useful information about nutrient sources but it is unlikely that it would apply to river basins in other areas.

As an example, the nutrient sources entering Upper Klamath Lake in Oregon have been reported by Miller and Tash (*24*). Although they did not express their findings in nutrient losses per acre, they did assign nutrients to various sources as shown in table 2. Contrary to findings in the Potomac River Basin, agricultural drainage appears to be an important source of phosphorus as well as nitrogen. In addition, water from springs was found to supply considerable phosphorus. Miller and Tash (*24*) do not comment on this source, but it indicates a possible pollution of ground water with phosphorus not reported before.

These, as well as other studies, have also shown that the yield of nutrients from watersheds is strongly dependent on stream flow. Several conse-

TABLE 2.—*Estimates of sources of plant nutrients entering Upper Klamath Lake, Oregon*

Source	N	P
	Percent	
Pristine streams	0.4	0.4
Agricultural drainage	20.1	26.5
Canals	9.8	5.1
Springs	11.4	24.9
Major rivers	58.4	43.0

quences of this dependence are examined next.

Extensive stream monitoring by the U.S. Geological Survey has established that the concentration of most dissolved constituents is related to flow. These findings, which are largely measurements of conductivity and chlorides, have shown that concentrations are generally highest at low flow and are diluted during periods of high flow. Concentrations of nitrogen and phosphorus, however, do not always follow this pattern. In the Potomac River Basin (*16*), the concentration of nitrite plus nitrate nitrogen was found to increase considerably as flow increased, while total Kjeldahl nitrogen and total phosphorus decreased only slightly with increased flow.

Harmeson, *et al.* (*14*), found in watersheds in Illinois where nitrates were scarce that no correlation existed between flow and nitrate concentration. However, in three rivers with high nitrate concentrations, correlation coefficients between nitrate and flow were 0.69, 0.80, and 0.84. Frink (unpublished data) found in the Housatonic River Basin in Connecticut that at most sampling stations, chloride decreased with increasing flow as expected. However, the relationships of nitrate nitrogen, total Kjeldahl nitrogen, and phosphorus to flow depended on stream characteristics and generally were not strongly correlated.

Harmeson, *et al.* (*14*), suggested that the increase of nitrate nitrogen with increasing flow was diagnostic evidence that nitrate was supplied by land runoff, since nitrate in wastewater discharges should be diluted at high flow. This seems a reasonable assumption, since peak flows in the spring should coincide with the onset of nitrification and thus an increase in nitrate available for leaching. This is not necessarily attributable to agricultural fertilizer, however, since the soils of the Midwest are high in native organic nitrogen and would produce a similar response. Larson (private communication) has attempted to separate sources of nitrate in Illinois streams into these two categories, namely fertilizers and soil organic nitrogen, by measurements of the isotopic distribution of N^{15} and N^{14}. This approach assumes that fertilizer nitrogen has the same isotopic composition as atmospheric nitrogen, which biological or soil nitrogen is enriched in N^{15}. Recent work by Dewiche and Steyn (*10*) has shown, however, that no fixed isotopic ratio can be assigned to soil nitrogen because of the complexity of the reactions involved. Thus, although this approach is certainly promising, the results of such calculations should be viewed with caution.

One other consequence of the relationship of nutrient concentration to flow is evident when nutrient budgets are calculated. Since nutrient concentrations in the Housatonic River varied only two or threefold, while flow varied 10- to 100-fold (Frink, unpublished data), the majority of nutrients were transported during high flow periods. This may be particularly true for nitrate nitrogen (*14*) and indicates the importance of concentrating sampling observations during periods of high flow.

Thus, these measurements in various watersheds have produced useful information regarding the contributions of man's various activities to the nutrient yield to waterways. However, other approaches may be equally useful and avoid the high cost of national water monitoring.

Farming Systems

CORN is grown on 65 million acres in the United States and utilizes 40 percent of our total nitrogen fertilizer production. Rather than monitor the runoff from these 65 million acres, perhaps we should examine nutrient losses when corn is grown by various systems. Lathwell, *et al.* (*18*), have examined the efficiency of nitrogen utilization by corn as affected by rate, method, and time of application. Their experiments in New York, as well as a review of much other experimental work, led them to conclude that proper timing of application had the greatest influence on the efficiency of utilization of nitrogen fertilizer. They state:

"The longer fertilizer N remains in the soil, the greater is the probability of loss by one mechanism or another. Less N, therefore, will be required to produce the same yield the closer it can be applied to the time of maximum demand by the crop. For corn, summer sidedress applications fit this requirement. The number of experiments made under the wide variety of conditions examined here lead us to conclude that to get maximum efficiency and to minimize environmental pollution most, if not all, fertilizer N applied to corn should be summer sidedressed."

What could be clearer? Our goal as agricultural scientists is twofold: Produce the necessary food and fiber with the least damage to our environment.

Lathwell, *et al.* (*18*), have shown that summer sidedressing of corn fits these two requirements. Although we may not know exactly how many pounds of nitrogen are lost when corn is planted on a particular silt loam with a 3.5 percent slope, under 40 inches of rainfall, at three different rates of nitrogen from four sources, we do know that these losses are minimized if the fertilizer is applied to the growing crop. Thus, I see no reason to delay in implementing their suggestion.

Further west in soil region 6–12, where runoff is much less and native soil fertility is high, the potential for nitrate pollution depends primarily on the amount and distribution of precipitation (*27*). Normally, in this area of dryland agriculture, soils dry to a depth of at least 3 feet during the cropping season. As the soils wet from the surface downward during the noncrop season, any nitrate is carried down with the water. The water is then used by the subsequent crop, with little upward movement of the deposited nitrate. As long as nitrogen removal in the crop exceeds the amount added in fertilizer, this pool of nitrate should be small. In occasional years, however, soils are wetted to depths of 6 feet, carrying nitrate beyond the recovery zone of most crops. Thus, if excess fertilizer has been used, this occasional deep wetting will deposit nitrogen below the roots of crops. The time for the nitrate to travel further to ground water may be long, but the lesson is clear: Excess fertilizer nitrogen not removed in the crop will likely reach ground water.

In irrigated regions in California, Stout and Burau (*30*) describe two consequences of agricultural operations. At one site, strawberries had been grown for 5 years with relatively low fertilizer rates and conservative water use. The result: Ground water pumped from below and applied to the crop contained 27 p.p.m. nitrate (as N), while leaching water returned to ground water contained only 18 p.p.m.! Under these conditions of moderate fertilizer use and controlled irrigation, the growing crop actually purified the water passing through it. A nitrogen budget for the site, calculated from estimates of water pumped, fertilizer imported and crop exported, accounted for 90 percent of the nitrate nitrogen in the irrigation water.

At a second site, celery, a heavily fertilized crop, had been grown. Although the nitrate profile in the fine-textured soil at this site was more complex, they calculated that the irrigation water contained 42 p.p.m. nitrate nitrogen and that the leaching water returning to ground water could contain as much as 48 p.p.m. Stout and Burau (*30*) predict that increases in nitrate concentrations in underground reservoirs can be expected as population increases, owing to the needs for increased food production and waste disposal. I submit, however, that there is a lesson to be learned from the strawberry patch: Crops apparently can purify irrigation water rather than contaminate it if fertilization is adjusted to crop need.

A variation on this renovation of percolating ground water was reported in three irrigated areas along the upper Rio Grande (*5*). Here, although fertilizer use has increased as much as 100-fold during 1934–63, the nitrate nitrogen in irrigation return drains to the river has not increased measurably. Although lack of leaching of nitrogen beyond the roots could be the cause, Bower and Wilcox (*5*) suspect that denitrification of leached nitrate in the anaerobic zone near the water table is a more likely explanation. Microbiologists, long concerned with reducing losses of nitrogen by denitrification, should see this as evidence for a pressing need to learn how these losses may be enhanced.

Other analyses of farming systems could probably be found, but these illustrate the principle. Now we might inquire if similar studies of animal waste disposal have been made.

There are over 7 million dairy cows in the Northeastern and North-Central United States with an average 14 acres of cropland per cow (*22*). Unfortunately, the cost of hauling manure to the field may exceed its value as fertilizer. Thus, farm manure applied to corn was worth $1.50 per ton and to alfalfa was worth $1.94 per ton, while the cost of hauling and spreading varied from $1.92 to $3.18 per ton depending on the methods of handling (*22*). However, the costs to the environment of alternative methods of disposal are so great that land spreading appears the only feasible method in this humid part of the country.

Frink (*11, 12*) analyzed the utilization of dairy farm manure and fertilizer in a different fashion. Dairy farms in the Northeast were considered as factories for the conversion of inputs in feed and fertilizer into outputs in milk and meat. Since nutrients are cycled through the cow to the soil, taken up by plants and returned to the cow, no distinction was made between nutrients from feed or fertilizer.

Records of about 600 dairy farms participating in various farm accounting progams in 1966 and 1968 provided the necessary data for calculations of dairy farm nutrient budgets for each state; the results were expressed as calculated losses of nutrients per acre and related to available cropland per cow (fig. 3).

Previously, losses of nitrogen appeared as a linear function of farm size (*11*). Inclusion of calculated losses of phosphorus and potassium suggests that the relationship may be curvilinear. In any event, disappearance of nutrients increases dramatically as farm size decreases. Both phosphorus and potassium are assumed to be fixed in the soil and remain on the farm in unavailable forms. If manure is spread on frozen ground, however, the soil filter may be bypassed and nutrients may reach streams by overland runoff (*22*). Although little phosphorus may be lost to waterways as a result of improved farming practices, the disappearance of as much as 70 lbs. of phosphorus per acre is significant in view of our dwindling phosphorus reserves.

No such nitrogen fixation mechanisms exist when equilibrium with soil organic matter is reached; nitrogen was assumed to be lost from the farm and eventually reach ground water. Comparison of predicted and observed concentrations of nitrate nitrogen in the ground water in the milkshed region of eastern Connecticut supported this contention (*11*). Recent analyses of wells on individual dairy farms in Connecticut by the Connecticut State Department of Health (unpublished data) have revealed some analyses exceeding the U.S. Public Health Service drinking water standard of 10 p.p.m. nitrate-N, confirming predicted concentrations in wells under individual farms (*11*).

These analyses also revealed several ways in which the efficiency of nitrogen utilization by dairy farms could be improved, thereby reducing losses to the environment. First, owing to the strong dependence of nitrogen losses on farm size, it is evident that every effort should be made to keep available land in crops to soak up the applied nutrients.

Tax relief devices for farmers, such as the Open Spaces Acts in the Northeast and the Greenbelt program in California, are designed to do this and should be encouraged. Agronomic approaches include application of manure and fertilizer to the growing crop (*18*) rather than to bare or frozen soil, selection of crops for high yield and high protein content, increased plant populations, and winter cover crops (*12*). Thus, these practices should allow us to decrease the nitrogen imported onto a dairy farm, and simultaneously produce the same amount of milk with less damage to our environment. Again, although we may not know the exact losses from a particular dairy farm, we seem to have the necessary data to make some useful suggestions.

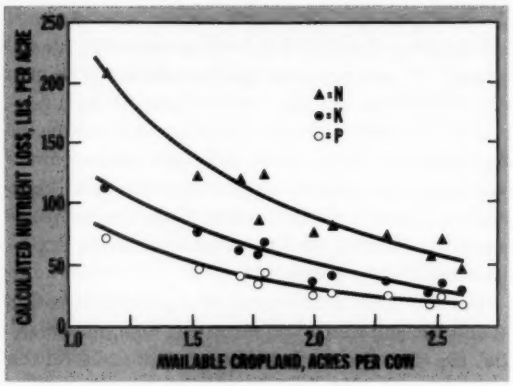

FIGURE 3.—Estimated losses of nutrients from dairy farms in the Northeast. Phosphorus and potassium are assumed to accumulate in the soil, but nitrogen is likely to be lost to waterways.

As previously mentioned, manure disposal in the drier Midwest and Plains presents a different problem. Here, recent studies (*23*) of a feedlot where little manure has been removed since 1956 suggest that the manure is best left to decompose in place. The manure pack and the manure-soil interface appear to have created a nearly impermeable seal over what had been a highly permeable soil. The lot is level, and under the prevailing climatic pattern no runoff occurs. According to Meilke, *et al.* (*23*), nitrate is produced in the aerobic manure pack and denitrified below this zone, where it is lost as gaseous nitrogen compounds. Much of this nitrogen is in the form of ammonia, however, which is readily trapped by nearby water surfaces (*15*). Although some enrichment of water may occur, these experiments suggest that manure on level lots where no runoff occurs is best left to decay anaerobically by "low temperature incineration." Thus, while intensive agriculture in the humid Northeast enhanced nutrient losses (*11, 12*), nutrient losses from manure

seem minimized in the Midwest by highly intensive land use. It appears to me that further study of intensive versus extensive agricultural operations might be rewarding.

Finally, a word should be said about studies of the ability of soil to renovate human wastes. Unfortunately, this is not presently considered good farming practice, but hopefully, this attitude will change. Early studies by Lunt (*19*) showed that sewage sludge was a satisfactory fertilizer provided that soil was alkaline enough to avoid toxicity from heavy metals. On a larger scale, Dalton, *et al.* (*8*), proposed that all sewage sludge from the Metropolitan Sanitary District of Greater Chicago be disposed on agricultural land. Recent reports (*25*) indicate that the project is a success and that organic gardening is not just an amateur sport. In another imaginative and well-known experiment, Kardos and his colleagues (*26*) have demonstrated that secondary sewage effluent can be renovated by utilizing soil as a "living filter," thereby fertilizing a crop and returning sparkling clean water to underground storage. Since the soil filter appears cheaper and more effective than most alternative methods, with the added virtue of recycling plant nutrients, efforts to utilize soil for disposal of human wastes should certainly be encouraged.

Political Units

SINCE decisions to provide clean water are frequently political, it seems appropriate to examine nutrient sources in a political unit to help us establish priorities in what promises to be a very expensive process.

Corey, *et al.* (*7*), reported a summary of their estimates of nitrogen and phosphorus reaching Wisconsin surface waters shown in table 3. These estimates were obtained in a manner similar to those reported in a study of nutrient sources for Lake Mendota (*3*), and are subject to some of the uncertainties of measurement previously discussed here and elsewhere (*11*). However, accepting the data as presented, we see that municipal wastes supply one-fourth the nitrogen and over one-half the phosphorus found in surface waters of Wisconsin. Thus, present efforts to remove phosphorus from domestic sewage effluent appear well justified.

Manure spread on frozen land is estimated to supply nearly one-fourth the total phosphorus in water; hence, restrictions on manure spreading are probably in order. Nearly one-half the nitrogen is estimated to be supplied by ground water; unfortunately, no estimates of sources of nitrogen in the ground water were given, although Biggar and Corey

TABLE 3.—*Estimates of sources of plant nutrients entering Wisconsin surface waters*

Source	N	P
	Percent	
Municipal treatment facilities	24.5	55.7
Private sewage systems	5.9	2.2
Industrial wastes	1.8	0.8
Rural sources:		
Manured lands	9.9	21.5
Other cropland	0.7	3.1
Forest land	0.5	0.3
Pasture, woodlot and other lands	0.7	2.9
Groundwater	42.0	2.3
Urban runoff	5.5	10.0
Rainfall on water areas	8.5	1.2

TABLE 4.—*Estimates of sources of plant nutrients in Connecticut*

Source	Material	N	P
	Tons	*Tons*	*Tons*
People—3,000,000	1,500,000	13,500	4,500
Cows—100,000	1,500,000	7,500	1,600
Broilers—12,000,000	240,000	3,600	840
Layers—4,000,000	80,000	1,200	280
Dairy and poultry feed	444,000	13,300	3,100
Dairy farm fertilizer	26,100	2,500	1,300
Other agricultural fertilizer	29,100	2,100	1,000
Nonagricultural fertilizer	25,600	2,800	1,400
Automobile exhaust		38,400	
Other combustion		59,200	
Protein produced in State		3,800	
Protein imported into State		14,000	

(*3*) indicate that agricultural drainage supplies a considerable proportion. Data such as these surely could be useful in assessing cost benefit ratios of proposals to provide clean water in Wisconsin.

Frink (*13*) demonstrated the magnitude of various possible nutrient sources in Connecticut as shown in table 4. Not all these sources are additive; for example, the nutrients that entered the state in feed and fertilizer also reappear in both human and animal wastes. Not all these wastes reach streams, either, but rather should be considered only as potential sources.

Domestic wastes produced in Connecticut contain about as much nitrogen as animal wastes, but nearly twice the phosphorus. At least 60 percent of these domestic wastes are treated in sewage treatment plants, so that the soil filter is bypassed and nutrients are discharged directly to streams. Since sewage treatment plants are constantly being built, nutrient pollution of waterways from this source can be expected to increase. Inasmuch as half the phosphorus in domestic wastes has been attributed to detergents, current enthusiasm for banning phosphates in detergents is high. Space does not permit a discussion of the arguments for and against this ban. Suffice it to say, however, that if technology assessment fails to predict the impact on the environment of the massive introduction of phosphate substitutes, science as well as the environment, will be in trouble.

Most plant nutrients first enter Connecticut as dairy and poultry concentrate, rather than as fertilizer. The study (*11, 12*) of nutrient cycling on dairy farms illustrated how losses from these sources can be minimized. Poultry farmers have long since ceased growing their own feed and hence often have little land available for spreading manure. Not all agricultural land grows annual crops, however, and Stephens and Hill (*29*) are currently investigating the utilization of liquid poultry manure by a stand of white pine. Nearly two-thirds of Connecticut is forested and, we presume, would benefit considerably from the nutrients in wastes.

Of the total fertilizer used in Connecticut, nearly 40 percent is sold for nonagricultural purposes. Since much of this is used on lawns where the harvested crop is not utilized, such use may well be a significant source of nutrient pollution. This suggests that a tax on nonfarm fertilizer might reduce its use and thus reduce pollution from

this source. At the very least, we can tell surburban homeowners that green lawns may lead to green lakes.

Finally, the nitrogen oxides NO and NO_2 produced during high temperature combustion are another large and uncertain source of nitrogen. Previous reports of these sources in Connecticut (*13*) were based on estimates by the U.S. Public Health Service of emissions of nitrogen oxides for the United States in 1965. These were reduced to elemental nitrogen by assuming "nitrogen oxides" were 40 percent nitrogen. These amounts seemed high, but for 1968 the Council on Environmental Quality (*31*) reported 8.1 million tons from transportation and 12.5 million tons from other sources, an increase of nearly 60 percent over the 13 million tons estimated for 1965.

Using these data, the ratio of automobiles registered in Connecticut to those registered in the United States and assuming "nitrogen oxides" are 30 percent nitrogen (as in NO_2), we arrive at the estimates for automobiles shown in table 4. Since Connecticut is highly industrialized, the ratio of 12.5 to 8.2 for other sources relative to automobiles seems realistic and was used to derive the nitrogen from other combustion sources. An alternative for automotive sources would combine an emisison factor of 0.113 lb. NO_2 per gallon of gasoline (*28*) with sales in Connecticut of about 1 billion gallons of gas annually, which leads to a lower estimate of about 17,000 tons of N emitted annually. Thus, there is an uncertainty of about a factor of two in these estimates.

Assuming that both NO and NO_2 return largely as nitrate in rainfall (*28*), the amounts shown in Table 4 correspond to about 65 lbs. N/acre. Obviously, not all of this returns to Connecticut or we would have little need for fertilizer. Unpublished data from lysimeters at the Connecticut Agricultural Experiment Station indicate inputs of nitrate in rainfall as high as 13 lbs. N/acre. Unfortunately, these experiments ended in 1945 so that possible increases with increasing urbanization cannot be examined. Nevertheless, this appears an important source of nitrogen in urban areas which merits further examination.

The last item in table 4 provides an estimate of the productivity of agriculture in Connecticut. Protein, equivalent to fully 20 percent of that consumed in Connecticut, is produced by our efficient farmers. This is equivalent to feeding 20 percent of the population, or about 600,000 people. Since there are only about 2,000 farmers in the State, 300 Connecticut citizens depend on one farmer for their animal and vegetable protein. Again, this is valuable data when the need for plentiful food is weighed against the desire for clean water.

SUMMARY AND CONCLUSIONS

ON a national average, more nutrients are removed in crops than are applied in fertilizer. Hence, some agricultural spokesmen have concluded that agriculture cannot be contributing to nutrient pollution. An inspection of agriculture in various regions of the country reveals the fallacy of this argument; some farmers add more nutrients than their crops recover, while others are mining native soil fertility.

Nutrient yields to waterways were then examined in three ways: direct measurements in watersheds, analysis of farming systems, and calculations for political subdivisions.

Direct measurements in watersheds have shown, for example, that agricultural runoff supplied significant quantities of nitrogen in the Potomac River Basin but was not an important source of phosphorus. Measurements in other watersheds with different densities of farmers and urbanites produced different results; consequently, widespread measurements would be required.

To avoid the great cost of a national water monitoring network, as well as to discover remedies, I propose that we analyze various farming systems. For example, corn is grown on about 65 million acres in the United States. It has now been amply demonstrated that losses of nitrogen from a corn crop are minimized if all fertilizer nitrogen is applied by summer sidedressing. Similarly, losses of nutrients from dairy farms were found to be minimized if adequate cropland was available to efficiently soak up nutrients in the applied manure and fertilizer.

Studies in irrigated regions have shown that, if fertilizer applications are tailored to crop need, ground water can actually be purified by cycling it through a crop. Sewage effluent, another large source of nutrients, may be renovated by utilizing the purifying abilities of a soil-crop filter rather than

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the diluting power of streams. Since our goal is the production of food and fiber with the least damage to our environment, these studies clearly show the way.

The calculations of nutrient sources for political units should help us establish priorities in the expensive process of providing clean water. For example, in Wisconsin, manure spread on frozen ground was estimated to supply nearly one-fourth the total phosphorus in surface waters. Hence, restrictions on manure spreading might be indicated.

As to further research needs, I propose, first, that we place less emphasis on water quality standards, except possibly for health hazards. Instead, we might consider that any increase in nutrients to waterways may increase growth of weeds and algae. Therefore, we ought to direct our efforts towards minimizing nutrient yields from all significant sources, and ask how much stopping the yield will cost society.

Microbiologists have long studied how to enhance fixation of atmospheric nitrogen and promote the conversion of soil nitrogen to the soluble nitrate. Now, they must learn how to return nitrogen in human and animal wastes to the atmosphere for storage as nitrogen gas, and to retard the formation of soluble nitrate in soil until it may be taken up by a growing crop. Chemists have studied how soil phosphorus may be solublized and made more available to crops. Now, they must learn how to render phosphorus less soluble in sewage treatment plants and lake sediments. For years soil scientists have attempted to increase the organic matter content of soils with little success. Now, they can utilize the results from their least successful experiments to learn to speed the decomposition of organic wastes applied to soils.

Geneticists have provided us with high-yielding crops that will tolerate high rates of nitrogen fertilizer. Now, they must learn to select crops that will scavenge the soil for nitrogen and convert it into usable protein. Animals must be bred not only for higher production, but also for more efficient conversion of nitrogen in their feed into usable protein in meat, milk, and eggs. As a final comment, I would like to suggest that we abandon our preoccupation with obtaining the maximum yield per acre and consider instead a systems analysis of agricultural practices that will maximize all benefits to society. A study of intensive versus extensive agriculture might provide a starting point for such an analysis.

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Publish or Perish

IN this "publish or perish" atmosphere, we often forget that the end of research is truth—not publications. In setting a policy for publications, we'd like to keep this ideal in mind.

It is the obligation of every researcher to "publish" his findings so that the results of his work may be shared—not just because his promotions may depend upon how often he breaks into print. Publication can be in many forms. We would like to see research published in forms that will be most useful to the people who need it.

This is, of course, the ideal. Arriving at this goal will be difficult at first because it is easier to do things the way they have always been done. It is also quicker. We may continue in many of the same paths in order not to add to the existing backlog of manuscripts awaiting print.

Currently, some communications "experts" are popularizing the myth: "There is a wealth of valuable research material that is buried in technical journals." They believe that it is their responsibility to nose it out, revise it, and publish it in a slick, readable form. We cannot afford to perpetuate this myth. If we do, we will inevitably be inundated by "the wealth of material" that should stay buried.

Hence our publication ground rules:

1. If you have something worth publishing, send it to a journal in your field. Send a copy to our information staff so we can report your activities to our funding agencies. You get points for this.

2. If the editor accepts your paper, let us know. You get more points if journal editors publish your manuscripts.

3. If, in your work, something arises that is more interesting than it is scientific, let us know. We will write a feature article and submit it to the various media, or arrange a press conference, or hire a blimp to advertise the event. You don't get many points for this, but we do.

4. If your work isn't worth publishing (or mentioning) but ought to be recorded somewhere to keep someone else from making the same fool mistake, let us know. We will have it multilithed and provide some nice covers to camouflage your mistakes. But keep such works to a minimum because we don't want to get into the publishing game. No one gets points for this.

5. If you come up with something that is of real value to the man on the street, call him and tell him. If he can use your idea, he may hire you as a consultant. To heck with points—dollars are what count!

6. Finally, everyone sometimes gets the urge to write a dull, incomprehensible paper on a subject of interest only to himself. Do not subdue this urge—it might harm your psyche. Write the thing, and send it to us with the recommendation that it not be published. We will decently inter all drivel received in this manner and record for posterity your public-spirited action. The nonauthor with the most non-publications to his credit will be guest of honor at our annual Non-Publication-in-the-Interest-of-Science Dinner.

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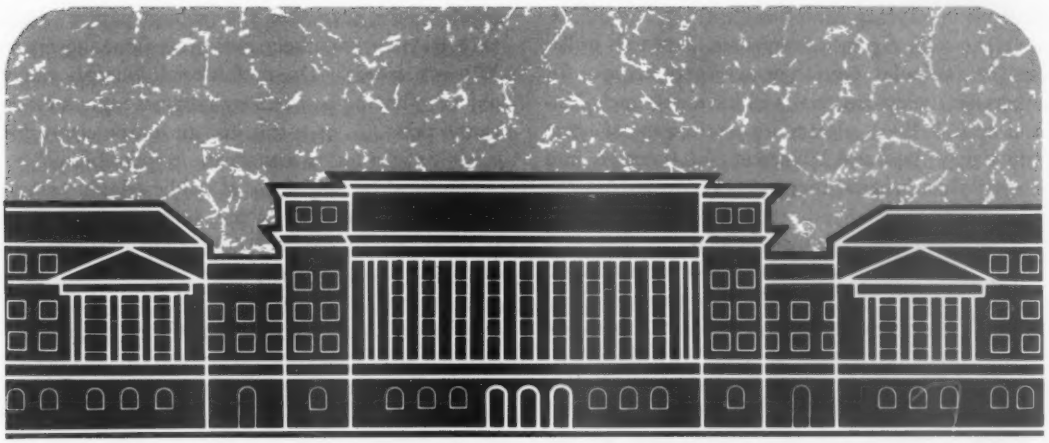

AGRICULTURAL SCIENCE COMMUNICATION

Report of a National Seminar

AGRICULTURAL journalists are a bunch of fat cats who refuse to believe that agriculture is not news anymore." So spoke one of the participants at a recent national seminar on agricultural science communication.

To a certain degree, this bit of commentary epitomized somewhat bluntly one of the very reasons for holding such a conference. After a century of telling farmers how to raise yields on the "back forty," agricultural journalists have realized that new approaches are needed to put agricultural science reporting in proper perspective. To that end, therefore, about 125 agricultural administrators, writers, and, editors met in Washington, D.C., January 25–28, 1971, to discuss their common problems in communication and, hopefully, to arrive at some solutions.

The seminar was sponsored by the Office of Information and the Agricultural Research Service of the U.S. Department of Agriculture and the Experiment Station Committee on Organization and Policy. Through the presentation of formal papers and followup discussions, conference planners had hoped to give participants an opportunity to (a) examine techniques that differentiate science reporting from other kinds of journalism, (b) identify ways to make agricultural science reporting more meaningful to the general public, and (c) share experiences and formulate ideas that could lead to positive action.

Because proceedings of the seminar have already been published, *Review* will attempt in this article to go beyond a mere summary report and put the seminar itself in perspective by including evaluations and reactions of the participants themselves, particularly during the discussion sessions.

The two papers that aroused the most discussion at this seminar were those by Dr. Sylvan H. Wittwer, Assistant Dean, College of Agriculture and Natural Resources, Michigan State University, and Dr. Lynton K. Caldwell, Professor of Political Science and Director of Science Policy Studies, Indiana University. Both men came up with provocative—sometimes shocking—ideas, and then followed through with innovative suggestions which, in their view, could give more relevancy and meaning to agricultural science reporting.

An Administrator's Viewpoint

DR. Wittwer made most of the seminar participants sit up and take notice when early in his talk, he said agricultural communication has made little

progress in 50 years. Most State and USDA publications, he said, are in a sorry state. Research bulletins, in particular, are a hideaway and soft spot for otherwise useless material and have extremely limited appeal. Press releases are reminiscent of horse and buggy days and 90 percent of them go into wastebaskets because they contain no newsworthy information.

Wittwer challenged his audience to fight the "ivory tower" syndrome, in which scientists isolate themselves from the real world, by teaching them that they need to communicate to the masses of people rather than those in their own discipline. He said, however, it would be difficult to do this because of scientists' apathy toward the present information systems. "So let's get on with the job of changing the services and not the customers," he concluded.

Wittwer's statement that agricultural journalists are not always communicating the right information to the right audience was not exactly news to those in the audience who were members of the American Association of Agricultural College Editors (AAACE). This same theme has been expounded a number of times by invited speakers and members alike at AAACE meetings. But this accusation from an agricultural administrator—coupled with the fact that he acknowledged administrators themselves are partly to blame for the condition—gave a new twist to the problem.

"Scientists should be encouraged to write for the public as well as for those in their discipline *and get credit for it,*" he declared. "Many investigators are reluctant to give information to communicators until it has been published in their professional journals. They often, however, discuss this same information at a field day, in a radio interview or a telecast. Information people ought to be utilized in writing the story and having it proofed by the scientist, rather than having the material picked up by an outside reporter and released without being checked. Publications are often prepared for campus conferences and then the top of each paper has the inscription *"Not for Publication."* I often wonder to whom that message is directed. Greater trust and confidence need to be established between our scientists and those in communications."

Experiment station editors at the seminar were encouraged to hear Wittwer say that scientists should simultaneously prepare articles for the mass media at the same time they submit papers to science journals and their own professional societies. Wittwer asked: "Do professional journals really object to having preliminary progress reports made to the press . . . or is this just an escape clause for scientists who fail to assume the responsibility?"

He urged the setting up of public relations councils at the State level, which, through the activity of a paid staffer, would arrange press meetings and briefing sessions for key personalities on the State's research staff.

Wittwer mentioned the recent corn blight scare as a marvelous springboard to better communicate to the American people an appreciation of agricultural research—and that we live on a thin line of abundance. "Has the public really been informed," he asked, "that the Soil and Water Conservation Service, which has been in action for 40 years, is a veteran amongst a flood of newcomer ecologists and conservationists?"

Somewhat of a crusader in his approach to the science-writing role of agricultural journalists, Wittwer said they should capitalize on the public appetite for wanting to know more about the wonders of science. "We need to glamorize, popularize, and romanticize the results of agricultural science," he declared. This type of writing, he insisted, should require an open-door policy between administrators, communicators, and scientists.

Wittwer said if agriculturists are really sincere about wanting to do a better job in telling the story of agricultural science and its accomplishments, then more money ought to be set aside for effective communication of these results to the masses of people.

"Only one-half to about 2 percent of the total budget of State experiment stations is allocated to the dissemination of information. We need to get top-flight communication people on our staff and pay enough to keep them. It is going to be more expensive to popularize, romanticize, to glamorize and to mystify, but we can increase our efficiency by doing away with the hard printed pages that have for many years communicated only to members of our discipline or to other administrators. May I challenge the editors in this audience to come up with ideas and methods for getting the job done? Then [I challenge] research administrators and directors to be ready to fund and implement."

During the discussion period that followed Witt-

wer's talk, it was plainly apparent that seminar participants—particularly the writer-editor segment—were quite aware of the importance and urgency of Wittwer's challenges. A number of ideas were kicked around. One participant said he thought State information people spend too much time covering awards, promotions, and other functions. Another countered: "These things are important to the local populace." At the conclusion of the discussion period, in response to one participant who kept asking, "What do we do when we get back to our stations?" the consensus of the group seemed to be that the editors should meet with their colleagues, extension specialists, and department heads to tell them about the seminar and to explain the need for a new emphasis, and to seek alternative methods for getting their messages across.

A Changing Agriculture and a Changing Public

ALTHOUGH acknowledging the same communication problems expounded by Wittwer, Dr. Lynton K. Caldwell of Indiana University took a somewhat different approach to their analysis and solution.

"The proposition that I would like to lay before you," he explained, "is that our communication is indeed not adequate and that the reasons for its inadequacy extend far beyond the communications process itself. If we are to act effectively on the procedural or technical problems of communication we must take account of the profound changes both in agricultural science and in the life style, economy, and public attitudes of the American people. The roots of our communication difficulties are not to be found in the misuse or neglect of the communications media, but are rather to be found in the changes in science and sociology occurring in contemporary American life."

Agriculture as an enterprise—and the Department of Agriculture as its public image—Caldwell continued, can no longer count on the favorable view of its activities that generally prevailed in the past. Past achievements have either been taken for granted or else forgotten. Most Americans, he said, are now wondering what agriculture is doing for them, or *to them,* now. And agriculturists who are unhappy about this condition are not going to change this public attitude of skepticism and alienation just by expressing moral indignation.

Most people, Caldwell pointed out, have little concern for or contact with agriculture, and for this reason, maintaining communication with them requires more than just transmitting information. Agencies must listen and learn, in addition to sending out releases, if they expect to gain the confidence and understanding of the public. Programs that get out of touch with the public usually get in trouble, and there are signs that this may be the case with agriculture, he suggested.

"It would indeed be surprising," Caldwell continued, "if agricultural science, drawing upon its experience in applying science to coordinating human efforts had nothing to teach the rest of society struggling with behavioral and environmental problems. But agricultural science can also help by identifying its mistakes as well as its successes. Perhaps its biggest mistake, which in fact is a defect of its virtues, has been an overriding consideration for productivity as against all other considerations. This is not to say that other goals have been ignored. The defect has been that emphasis on agricultural productivity has not been tempered sufficiently in consideration of other legitimate concerns in the use of land."

The big problem, as Caldwell viewed it, is not so much *how* the messages are communicated, but *what* is being communicated and to whom. Although he did not specify exactly the nature of the desired messages, he questioned the wholesale dissemination of agricultural science news to the general public. Instead, he placed more emphasis on the kinds of messages that are inferred by the public as a result of either favorable or unfavorable actions and programs conducted by public agencies. He called these "defects of bureaucracy," citing as one example the involvement of the Department of Agriculture in the handling of pesticide registrations and "chemical warfare" on pests such as the fire ant. He interpreted the transfer of registration functions to the new Environmental Protection Agency as one of the outcomes of public dissatisfaction with a program.

"Failure to apply multiple-use concepts effectively to agricultural land," he charges, "has increasingly put agricultural science in a conflict position with the environmental quality movement. Widespread agricultural monoculture has created monotonous and ecologically unstable environments over large sections of the United States. Agricultural

specialists find new ways of making crop production more efficient, but frequently at the cost of environmental impoverishment.

"The place of agricultural science in the public programs and budgets of the United States," he concluded, "will be determined in a significant measure by the kind of dialog that has been established between agricultural science, its special publics and the American public at large. To be meaningful this dialog must include discussion of the ways in which agriculture affects the full range of values of the American people, not merely its role in meeting basic consumption needs. Thus, if for no other reason than to better define its goals and responsibilities in the American public's service, the communications task of agricultural science needs to be improved."

Most of the conference participants seemed to agree in principle with Caldwell's concept that the public was getting the wrong message. The only alternative action for agricultural editors, according to one discussion group, was to establish different priorities for reporting agricultural research. Some of the editors, however, seemed to be frustrated about the problem as to how agricultural journalists might be able to exert influence on agricultural programs and methods of implementing them.

One participant suggested that editors could choose *not* to issue stories that would create wrong impressions about agriculture among the general public. Another suggestion was that more communications research ought to be conducted, particularly in the area of getting feedback from those who are critical of agriculture and agricultural science.

The chairman of one discussion group summed things up succinctly by saying: "Caldwell has left us with a real dilemma."

The Plight of All Sciences

PHILIP H. Abelson, editor of the prestigious magazine, *Science,* said all branches of science face the common problem of communicating effectively with the public. This problem arises for two reasons: (1) The complexity and great detail of information resulting from research, and (2) the fact that many scientists are introverts whose academic training has ill-fitted them for communicating with people other than their peers. The real burden of carrying on such communication, therefore, falls on administrators and information officers—both in planning and in executing effective interaction with the public.

One way out of this dilemma, Abelson noted, would be to "develop a new breed of highly trained communicators—men and women who have successfully completed scientific training and who have excellent judgment as to what is important, significant, and salable. They must have a talent for writing and for informing others and be able to interest and hold audiences from the kindergarten to postdoctoral levels. Because of their understanding of the scientific frontier, they could interact easily with even specialized scientists who would welcome discussions with them. Because of an ability to put their feet in the other person's shoes they could transform the scientific information into understandable material of interest to general audiences."

Abelson stressed the need for agricultural journalists to avoid putting any of their agency's science staff in situations where they might not create a good image for their discipline. We have to face the fact, he said, that some scientists do a poor job when confronted with the press. If they can't be trained to handle the press properly, then the information officers should take over.

Science and Social Issues

TOUCHING on the philosophical issues of science reporting, Dr. P. J. Tichenor of the University of Minnesota noted that the growing involvement of science and technology in social problems is forcing journalists to broaden their former narrow role of merely reporting new discoveries and findings.

Mass media increasingly are dealing with questions about who gets funds, what problems will be studied, and whether scientists should take part in public decisions about the applications of new technology. As a result of this broader role, Tichenor said, nonscientists are no longer willing to let scientists, by themselves, decide what problems ought to be studied.

Tichenor told seminar participants that social conflict over fluoridation and cigarette smoking in the 1950's should have tipped us off to the possibility that some fundamental cleavages may exist

among research experts and between scientists and other interest groups. Thus, he observed, we may be witnessing the development of a period when science may be subjected to critical writing the same as other areas of social endeavor.

Much of Tichenor's paper was devoted to a summary and evaluation of pertinent communications research, particularly that related to science reporting. Although *Review* does not wish to minimize the importance of Tichenor's summaries to the issues of the seminar itself, space limitations require that such coverage be assigned to the pages of the official proceedings.

"Writers may do well to remember," Tichenor concluded, "that much of the motivation to report science today comes from the research community itself. A rising level of professionalism in science writing could reduce much of the journalistic apprehension based on status differences. Whether such levels of professionalism, in fact, increase may depend both upon training of writers themselves, and on willingness of media and information organizations to accommodate and reward writers on a basis that makes them professionally comparable to research scientists."

Vignettes and Pulses

IF the final session of the seminar had been held on the first day, an impartial observer might have wondered why agricultrual journalists thought it necessary to even hold such a seminar. For it was during this last session that selected State and USDA agencies presented vignettes of remarkably successful case studies of communicating science information to nonagricultural people.

The audience was particularly impressed with presentations by the Maryland and Ohio delegations on "open house" events, by the Pennsylvania vignette on telling the story of agricultural science to legislators, by the Georgia group's account of telling the "big story"—corn blight—to the press, and by the Vermont vignette on reaching specific audiences with selected kinds of publications. Presumably, all the 14 vignettes had been carefully chosen because they represented some of the best communications efforts known to the seminar planning committee. One might also assume that, had time permitted, this session might have run for the entire day so that other successful case studies could have been presented.

Even in retrospect, it is still difficult to read an accurate pulse on the seminar itself and the impressions of participants. Judging by comments picked up here and there and by the tempo of the six group discussions, one might reasonably conclude that the seminar was indeed a productive one. Some of the speakers' statements obviously did not "set" too well, but in turn they engendered vigorous discussions that seemed to have led to new concepts for more effective agricultural communication.

One point generally agreed upon was that agricultural journalists are faced with filling a tremendously important role in the immediate future. Although they may not feel that they have been accorded the full measure of status they deserve, their concern for the urgency of doing a better job of fulfilling that role may be the tipoff that agricultural journalists may well earn a new image for themselves—and perhaps for the agricultural disciplines and constituents they serve.

LETTERS

CORN BLIGHT AND EVOLUTION

IN the article, "A Colloquy on Corn Blight," (*Review, 8:4*) one of the authors said: "The fact that life appears to have existed on this planet for 21 billion years certainly seems to support the theory of biochemical evolution of life." The best and most widely accepted scientific estimate of the age of the Earth is 4.5 billion years, not 21 billion.

[Other readers also questioned this figure. Co-author Fulkerson advises that he had intended to use the word, *universe,* rather than *planet.*]

My main concern, however, is with the basis of the author's faith and logic for believing that pathogens will not take over and destroy life, including man. His faith appears to be grounded in the theory of biochemical evolution of life. I believe there is another and a better basis for faith as to the future.

Even if all life had been, or should be, killed off by a sudden preeminence of pathogens, would this disprove the biochemical theory of evolution? Could not what life that had existed have been the product of biochemical evolution? Anyhow, does the durability of life really support the biochemical theory any more than other theories?

It seems to me you are really saying that, from what we know, and from observing the history of life, one gains faith that the "pluses" are stronger than the "minuses" so there is upward progress in the gropings of life, or at least that the higher forms of life can hold their own.

There may be good "structural" reasons why the higher forms of life have held their own, against simplier forms, and the superiority of their sexual form of reproduction may be the main reason. It is my layman's impression that pathogens depend mostly and nearly entirely on vegetative reproduction. This being the case, pathogens have far less chance of coming up with new crosses, that is new gene combinations; in fact they are largely stuck with one set of gene combinations until a somatic mutation occurs. With sexual reproduction, thousands upon thousands of gene combinations can occur in every generation of any large population of open pollinated plants. In fact, every specimen can be a unique combination of genes and usually some specimen has a gene combination that is equal, or more than equal, to a new challenge. I know that some spore-forming organisms may under some circumstance also have sexual reproduction. But does sexual reproduction really play an important role in the virility of such organisms?

Although the simpler forms of life depend largely upon vegetative reproduction, they may have some advantage on the mutation side since they exist in such great numbers. However, some mutations also occur in the higher living organisms.

On the philosophical side, I also want to point out that commercial crops now also have the advantage of having science on their side. I believe that by science we can now arrive at gene combinations in a few years that would take nature thousands or millions of years to achieve. Secondly, we might even be able to achieve useful mutation in plants by radiation even though to date we have not been very successful at this. Thirdly, as pointed out in the article, we can continue to use highly productive, but pathogen-susceptible, breeding lines by use of pesticides.

It is encouraging to know that even though the range of genes in currently grown commercial crops is probably being narrowed greatly by modern science, we have had the foresight to maintain germ plasm banks. This means that even if the current commercial varieties are wiped out by a pathogen, our scientists can draw upon the great diversity of germ plasm that nature originally endowed some plants with. So an important reason for having faith and hope that viral bacterial and fungal diseases will not take over in the future should be that "good" plants have man on their side. This should be far more encouraging than the drawn-out processes of biochemical evolution. Also, pathogens have man against them and man is now better equipped to fight them than ever before.

The tendency of scientists to develop great theoretical constructions from a few facts and then to make these constructions an article of faith as to the future of life, the future of the universe, and the future of man bothers me. The theory of biochemical evolution, as usually presented, is really a mystical belief that purely by chance, by a series of accidents, life began and all life evolved. I would argue that it is just as scientific to believe that the progression we see in phylogeny and ontogeny was carefully planned and structured by a Great Mind.

(*Continued on page 39*)

ENVIRONMENTAL BENEFITS OF INTENSIVE CROP PRODUCTION

KEITH C. BARRONS

THROUGHOUT the current wave of concern for our environment, "more living space" appears high on priority lists of the world's needs. Naturalists believe that wilderness areas, wildlife preserves, and bird sanctuaries should be prime goals. Those interested in recreation plea for more campsites and multiple-use parks. Hunters want additional private and public land reserved for game, while people concerned with overcrowded cities talk about green belts and open space. An increase in land devoted to pulpwood and timber production is considered essential to man's welfare by those involved with resources for the future, while others want more forests for their natural beauty and for ecological diversification.

Even though one accepts the validity of all these demands for a share of the earth's surface, it must be recognized that the top priority use of land has always been and must continue to be for food production. Hopefully, an increasing proportion of our protein can be derived from fish and other aquatic life. Possibly micro-organisms produced on a fossil hydrocarbon substrate will make valuable contributions. But no matter how optimistic one's projections, most of our food in the foreseeable future must come from the land. If more and more land has to be used for crop production, there will be correspondingly less and less land available for other uses.

Modern agricultural technology has made a great

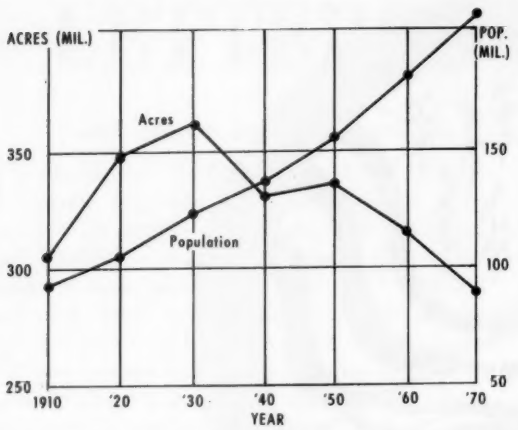

FIGURE 1.—Effect of increased yields on ratio of crop acreage harvested to population; United States, 1910–70.

contribution to a better environment through increasing crop yields, thereby reducing the acreage needed for food production. While many segments of the environment have degenerated in the last quarter century, vast areas of eroded agricultural land have been improved by diversion to forests, pasture, or various recreational uses. In spite of increased population and a corresponding demand for food, many technically advanced countries have fewer acres in crops today—excluding rangeland and permanent pasture—than they did a quarter century ago. Land "released" from cropping may now be put to one or another of the many uses that contribute to a better environment. If agriculture were no more productive now than it was prior to the revolutionary yield increases of the past 30 years, it is inevitable that vastly greater areas would be in farms today.

Crop Acreage vs. Population Trends

FIGURE 1 indicates the effect of increased yields during the recent agricultural revolution on the ratio of acres tilled to population in the United States.[1] The downward trend in the area cultivated is not due to a shift in foreign trade. U.S. exports of agricultural commodities have increased more rapidly than imports over the past 30 years. Although there has been some reduction in the per capita consumption of starchy foods, this change has been balanced acreage-wise by increased consumption of other foods including livestock products. The marked per capita reduction in area devoted to crops is largely a result of vastly increased yields per acre. Barring marked changes in diets or in foreign trade, the U.S. acreage curve should continue its downward trend so long as yields increase faster than population.

Geographic shifts in acres planted to crops in the United States between 1950 and 1970 are presented by region in table 1. The populous eastern portion of the country has experienced the greatest reduction—in part due to population growth—but even more to the poor adaptability of much of its land to today's mechanized farming. In contrast, some areas experiencing rapid population growth are maintaining or actually increasing their acreage in crops. Florida is one example.

The Yield Revolution

STATISTICS on a few major crops will illustrate the truly revolutionary nature of the increased productivity per acre in the United Sates in recent years. Note the 100-year history of corn (maize) yields in figure 2. The 1960's showed an increase of more than 250 percent over the relatively constant yields of the seven decades prior to 1940. In

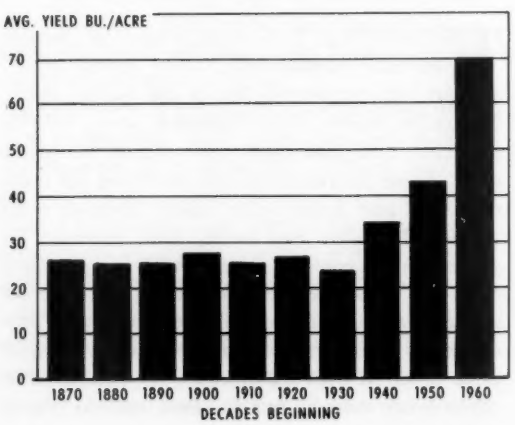

FIGURE 2.—100 years of U.S. corn production by decades.

[1] U.S. acreage and crop yield data presented in this paper were obtained from appropriate issues of *Agricultural Statistics* and from *Crop Production—1970 Annual Summary*, both published by the U.S. Department of Agriculture. Population data is from U.S. census figures in *Statistical Abstracts*, U.S. Department of Commerce, together with the published estimate for 1970 of 205 million.

TABLE 1.—*Harvested acres of crops in Continental United States by regions: 1950 compared with 1970*

Region	1950	1970
	Million acres	Million acres
North Atlantic	15.4	10.7
North Central	194.6	167.9
South Atlantic	24.0	16.7
South Central	64.2	54.0
Western	38.4	37.3

1969, average corn yields reached an all-time high of 83.9 bu./A. In spite of losses, due in part to Southern corn blight, the 1970 average U.S. yield of 71.7 bu./A. was still more than twice the average of the decade of the 1940's.

Figure 3 presents 100-year yield trends for three cereals—wheat, oats, and barley, while figure 4 gives a 100-year history of two other crops for which there are long term records—cotton and tobacco. Note the similar trends for these major U.S. crops.

Comparable yield increases have occurred with most crops in the technically advanced parts of the world. For example, potato yields in France increased from 97 to 208 one hundred kilo units per hectare over the last 30 years. In the 1930's, Japan produced what were then among the world's highest rice yields, yet advances in production technology have resulted in an increase of approximately 50 percent during post-war years.[2] Jacks[3] has traced the yield of wheat in Britain since 1100 AD (fig. 5). Note the marked climb during recent decades after centuries of stagnation or slow increases.

Land "Released" Through Yield Increases

HOW much space does the United States now have available for optional uses that would probably still be in crops if today's yields were the same as they were 30 years ago? A calculation of the acreage that would be required to produce the total crop volume of recent years at the yield per acre experienced before modern technology came into full play will give us some clue. To avoid misrepresentation by statistics of a single year's crop, averages were calculated for the 3-year periods, 1938–40 and 1968–70. The former period came after the severe drought of the mid-1930's yet was prior to the influences of World War II. Yields during the years 1968–70 reflected the full impact of

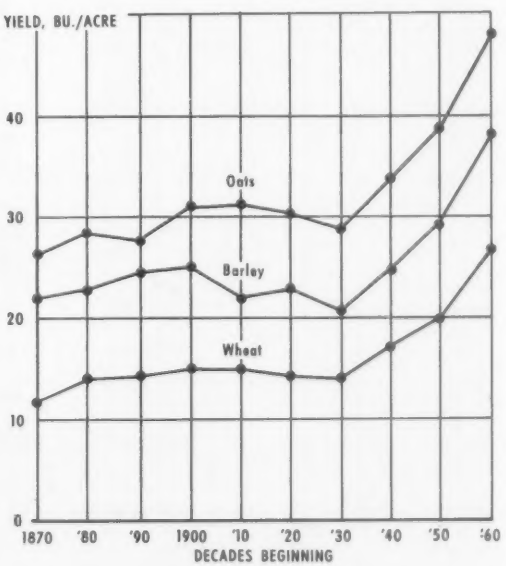

FIGURE 3.—Yields of three small grains in the United States, 1870–1960.

[2] Data provided by the Foreign Agricultural Service, U.S. Department of Agriculture.

[3] J. V. Jacks, J. SOIL AND WATER CONSERVATION 17: 147, 1962. Figure 5 was constructed from graphic data in this paper supplemented with British wheat yields for the 1960's from *Annual Review and Determination of Guarantees*, Ministry of Agriculture, Great Britain, March 1970.

the new crop production technology, yet this average includes the somewhat lower productivity of several crops during 1970. The following calculations on corn in the United States will serve as a model:

Average corn production 1968–70: 4362 million bushels.
Grown on an average area of: 55.9 million acres.
At an average yield of: 78.0 bushels/acre.
Average yield for 1938–40 was: 28.4 bushels/acre.
Area needed for 1968–70 average crop at 1938–40 yield per acre (No. 1 dividend by No. 4): 153.6 million acres.
Land saved annually in 1968–70 through improved production technology (No. 5 minus No. 2): 97.7 million acres.

Table 2 presents similar calculations for 17 major U.S. crops including all of those planted on about a million acres each year. Note that the average annual savings in acreage for these crops during the period of 1968–70 through advanced agricultural technology as compared to 1938–40 was approximately 290 million acres, an area nearly as large as the entire United States east of the Mississippi and south of the Ohio. This area of 290 million acres is equivalent to the total 1970 cropland

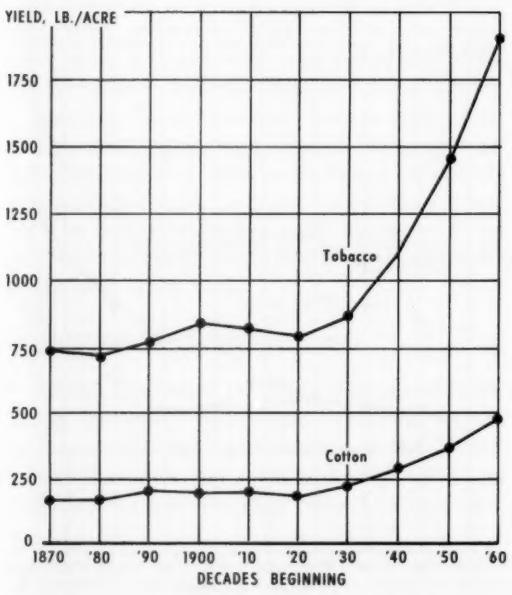

FIGURE 4.—Yields of cotton and tobacco in the United States, 1870–1960.

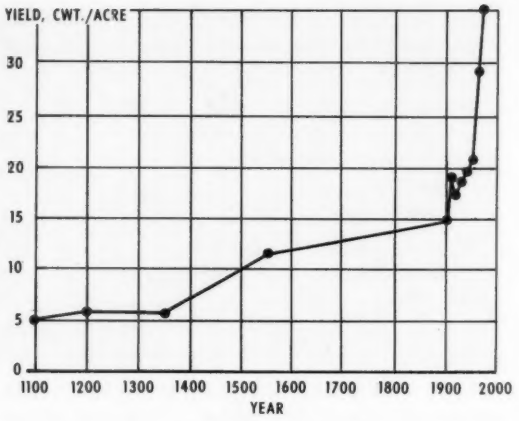

FIGURE 5.—Wheat yields in Britain since 1100 A.D.

in the United States. Thus, for each acre tilled today another acre is available for optional uses because of advances in crop production technology.

Agricultural technologists in the less technically developed parts of the world are striving to increase productivity per unit area. Considerable success has already been achieved, and it appears probable that the recent crop yield revolution in the technically advanced countries will be extended to much of the world during this century. Unless population increases faster than yields, these areas can, once a satisfactory diet is reached, also benefit ecologically through reduced acreage and the resulting availability of land for nonagricultural uses.

Parenthetically, let us hope that the recent downward trend in the area devoted to crop production will not lessen efforts to develop programs of sound land use with our better soils being reserved for agriculture. Let us also hope that recent agricultural progress will not lull the world into complacency with regard to our continuing top priority need for population control. It must be remembered that the potential for continuing yield increases is finite in contrast to man's infinite capacity to reproduce. It should also be remembered that as crops become more productive, further increases in yield tend to become more difficult to attain.

Contribution to Reduced Erosion

MAN'S first major insult to the environment was the pollution of streams with silt carried in runoff

water from sloping cropland or overgrazed pasture. Through the course of history, the accompanying soil erosion has practically ruined vast areas for productive farming. Agriculture still contributes a heavy load to many streams and loses much valuable soil. Although farmers have a long way to go in erosion control, tremendous progress has been made during the past few decades through terracing, stripcropping, and the establishment of sod drainage channels. Stubble mulch farming, now widely practiced in semi-arid areas, has greatly reduced the likelihood of wind erosion. New minimum tillage and zero tillage farming methods are making further contributions to the protection of soil from erosion.

Great progress has also been made in lessening erosion and concomitant silting through reduced acreages of tilled crops, particularly in hilly country, and the conversion of this land to pasture and forest as well as to various nonagricultural uses. If we were still obtaining the same yields that prevailed 30 years ago, much of the greater crop acreage that would be in production today would be on erodable land ill-adapted to tillage.

Today's high yields are equated with close plant spacing and vigorous growth. More unharvested portions of crop plants including roots are left in and on the soil when yields are high. These heavier crop residues contribute to an improved physical condition of the soil, better rainfall penetration, and reduced erosion. Thus, recent yield increases have contributed to conservation of the land that is still

TABLE 2.—*U.S. acres saved annually for optional uses during the period 1968–70 as a result of increases in yield since the period 1938–40*

Crop	1968–70 production (in millions)	Millions of acres, 1968–70	1968–70 yield(acre)	1938–40 yield(acre)	Millions of acres needed to produce 1968–70 crop at 1938–40 yields	Millions of acres saved in 1968–70 through yield increases
Hay	126 tons	62.6	2 tons	1.3 tons	96.9	34.3
Corn (grain)	4,362 bushels	55.9	78 bushels	28.4 bushels	153.6	97.7
Wheat	1,470 bushels	48.6	30.1 bushels	14.2 bushels	103.5	54.9
Soybeans	1,121 bushels	41.5	27 bushels	19.2 bushels	58.4	16.9
Oats	932 bushels	18.0	51.8 bushels	31.3 bushels	29.8	11.8
Sorghum (grain)	725 bushels	13.7	52.9 bushels	13 bushels	55.8	42.1
Cotton	10.3 bales	10.7	0.96 bale	0.5 bale	20.6	9.9
Barley	419 bushels	9.6	43.5 bushels	23 bushels	18.2	8.6
Corn (silage)	94 tons	7.9	11.9 tons	7.5 tons	12.5	4.6
Flax	30.7 bushels	2.5	12.2 bushels	9.2 bushels	3.3	.8
Rice	92.5 hundredweight.	2.1	44.2 hundredweight.	22.7 hundredweight.	4.1	2.0
Sugar beets	25.3 tons	1.4	18.1 tons	12.5 tons	2.0	.6
Beans (edible)	18.6 hundredweight.	1.5	12.3 hundredweight.	8.9 hundredweight.	2.1	.6
Potatoes	310 hundredweight	1.4	221 hundredweight.	75.7 hundredweight.	4.1	2.7
Peanuts	26.8 hundredweight.	1.4	18.6 hundredweight	7.5 hundredweight.	3.6	2.2
Rye	31.1 bushels	1.3	24.1 bushels	12.1 bushels	2.5	1.2
Tobacco	1,806 pounds	.9	2,008 pounds	947 pounds	1.9	1.0
Total						291.9

farmed as well as that land which has been diverted to noncrop uses.

Origin of the Yield Revolution

WHAT was responsible for the remarkable yield increases that have been achieved? With some crop species, a reduction in acreage with resulting retirement of less fertile land has in itself contributed to an increase in average per acre yield, but this is by no means true of all. Grain sorghum, for example, was grown on an average of only 5.3 million acres in the years 1938–40 at a yield of 13 bushels per acre, while in the period 1968–70 a yield of 52.9 bushels per acre was obtained on 13.7 million acres. With most kinds of crops, yield increases are primarily the result of widespread application of advanced farming technology.

The past 30 years has seen the fulfillment of a century or more of dreams on the part of research workers striving for a more productive agriculture. Earlier progress was piecemeal. No sooner was one limiting production factor overcome than another took its place. In the past, improved varieties were often inadequately fertilized. Potentially good crops were severely damaged by insects or diseases. Then, about 30 years ago the results of research related to agriculture began to be put to work with a "systems" approach; average yields started their sharp climb when growers eliminated multiple limiting factors. The technical influences involved may be considered in five major categories:

1. **Farm Mechanization**—Although important to total productivity in labor-scarce countries, mechanization has generally been considered less vital to high yields if other essential inputs are available along with adequate labor. Nonetheless, even in labor-rich areas certain kinds of equipment make it possible to irrigate extensively and to more adequately perform planting, harvesting, and crop protection operations at the right time, thus increasing average yield.

2. **Genetically Improved Varieties and Hybrids**—The importance of breeding has been emphasized in recent news about increased yields obtained with dwarf Mexican wheat, hybrid corn, and "miracle" rice. Actually, there is no successful agricultural enterprise today that has not benefited from the advancements in genetics and the scientific breeding of the last century.

3. **Improved Management Practices**—Improved crop husbandry practices made possible through increased knowledge of soils, irrigation, and plant responses to their environment have contributed significantly to increased yields.

4. **Better Plant Nutrition**—Research over more than a century on the mineral nutrition of plants together with developments in the economic production of fertilizers by the chemical industry made possible today's vastly better nourished crops.

5. **Control of Damaging Pests**—The plant breeder has given us genetic resistance to many diseases, and research on crop management practices has pointed the way to mitigation of a number of pests. Many insects, mites, fungi, nematodes, and competitive weeds which so often reduced yields in earlier times are now kept in check by the use of crop protection chemicals.

In addition to production technology, there are many economic, political and social factors that influence high yields. Credit must be available before needed inputs can be satisfied and a grower must have incentive to risk these inputs in the form of reasonable assurance of a market for his produce at a profit. This market assurance depends on storage and transportation facilities as well as on purchasing power and on policies related to price stabilization. Nothing discourages a grower from risking the inputs required for high yields more than the specter of low prices as a result of market gluts at harvest time.

Remaining Environmental Problems

NOT all ecological influences of modern crop production have been on the plus side. If the several recently identified pollution problems can be solved, farmers and agricultural technologists will have made a significant additional contribution to environmental quality. Much has already been accomplished through research and regulation in limiting the use of biomagnified pesticides and in replacing them with ecologically safer materials. If overregulation does not discourage industry from continuing its search for better agricultural chemicals and if there is public and private collaboration on adequate but sensible safety evaluations, crop producers of the future can have safer and more effective pest control programs based on chemicals integrated with other methods of control.

The extent of the contributions of fertilizer to accelerated eutrophication as a result of runoff or leaching is still under investigation. Intensive cropping with close stands and quick succession of one crop following another as now being practiced tend to minimize fertilizer losses to ground water or streams as do modern erosion control practices such as stripcropping, terracing, and reduced tillage. Where fertilizer losses are indeed found to be a significant contributor to eutrophication or where ground water pollution may occur, new technology now under investigation will no doubt be available for general use; for example, coated fertilizers, nitrification control, and nitrate removal from impounded irrigation tailings. Hopefully, the use of proven soil conservation practices will become universal.

Burning of crop residues resulting in a contribution to air pollution is already a thing of the past in many areas, thanks to a better understanding of the importance of organic matter to soil fertility, to the availability of inexpensive nitrogen fertilizer necessary to support the decomposition of crop residues, and, in some instances, to new short-strawed grain varieties. Research on the utilization of heavy straws such as from rice, which cannot be readily incorporated with the soil, show promise of making a further contribution to a cleaner atmosphere.

Conclusions

THOSE who raise crops for their livelihood together with the scientists and technologists that serve them are the inevitable custodians of a sizable part of the earth's land surface. As a result of recent increases in yields they have contributed much to a better environment through the release of land to optional uses. Reduced acreage, soil conservation practices, and more intensive cropping have all contributed to less erosion and the concomitant silting of streams. Research underway on other forms of environmental pollution related to crop production shows great promise of making further positive contributions to a better environment.

LETTERS (*Continued from page 32*)

We may do better, at least the impact on the behavior of people might be better, if we place our faith in the benevolence of the Great Mind and on man as the extension of the Great Mind. Only if we do this can we escape the mechanical concept of life that man himself is only a hapless biochemical reaction running its course, only then can we believe that man is the captain of at least a part of his destiny and that man can transcend past history.

That mutation occurs within a specie is a fact, *not a theory;* that these mutations account for the progression of biological phylae and orders is theory and *not a fact.* The failure of radiation research to induce useful and superior germ plasm mutations or even superior somatic mutations is phenomenal. It seems to me that the survival of the higher forms of life in the face of pathogen challenges can best be explained by a concept of superior original endowment, not by drawn-out process of chance known as biochemical evolution. This does not deny the concept of useful mutations within a specie or even ordered evolution. The superior endowment of higher forms of life is principally in multitudinous alleles and superior forms of sexual reproduction. Also the defense response mechanism of the higher forms of life, antibody production for example, may be the other main endowment. The current and widespread acceptance of the theory of chance evolution of life and of man may some day be looked upon as a manifestation of modern man's wish to escape, or to hide from, ultimate accountability, a desire to be free to the extent of irresponsibility and a desire to be one of the gods.

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PAIN: Cultural Contexts in Research and Application

VICTOR A. CHRISTOPHERSON

As public debate rises on matters relating to rural development and the quality of rural life, it is becoming more and more apparent to some observers that certain social aspects may very well outrank the economic aspects in priority values. Indeed, many of the problems facing rural America today cannot be viewed productively as being separated from the people they affect. The fact that such realizations have been so late in coming not only adds a note of urgency to the situation, but also taxes the research resource facilities of the concerned institutions and public agencies. Some problems still await satisfactory approaches to methods of research; others, by virtue of their compex nature, simply remain unsolved. One of those in the latter category is chronic illness and its universal, debilitating symptom—pain.

Medical science has very nearly conquered the deadly diseases, but the ones which harass and nag while permitting life to coexist, go on. In fact the incidence of chronic illness is rising as the vulnerable segments of the population, such as the older groups, increase. Until the attendant problems of prevention, cure, and adequate delivery of health services are solved, amelioration of symptoms seems to be the approach to chronic illness with the greatest payoff. This is the point at which adequate attention to the people, both in cultural groups and as individuals, who suffer from various symptoms of chronic illness can yield high dividends. Limited research findings on the symptom of pain—not only from chronic illness, but also from injury—clearly indicate the social gains that could accrue from more intensive research effort in this field.

Historical Perspective

ATTEMPTS to evolve adequate concepts of pain and to define it go back many years. Aristotle considered pain an emotion which was the opposite of pleasure. This point of view apparently sufficed or was not expanded in any great detail for many centuries (*5*).[1] In the latter part of the 18th century, Erasmus Darwin suggested that pain resulted from overstimulation of any of the five traditional senses: hearing, sight, smell, taste, and touch. Most pain was considered as a product of the sense of touch (*4*).

During the 19th century it was recognized that there were cutaneous senses in addition to touch, notably senses of cold and heat. An 1858 work by Schiff cited by Bonica (*5*) suggested further that pain was a separate and distinct sense, independent of touch. In this period a theory of specificity evolved which held that specific fiber systems in the skin were especially sensitive to specific sensations

Paper No. 1744 of the Arizona Agricultural Experiment Station, The University of Arizona.

[1] Italic numbers in parentheses refer to Literature Cited, p. 44.

and insensitive to others (*17*). Certain nerve endings were thought to respond only to heat, others only to cold, others to touch, and others to pain.

More recently, the concept of specificity has been challenged (*16*), and a new and still controversial concept has emerged. This concept theorizes that pain is differentiated in the brain from other sensations by the patterns of impulses transmitted from the site of stimulus (*1, 4, 10, 19*). Supporters of this theory believe there are no specific nerve endings and no specific nerve pathways subserving pain, but that any nerve endings or pathways are potential pain pathways.

A comment appeared in the *British Medical Journal* (*8*) on the controversy as to whether specific fibers subserve specific sensations or whether the sensation perceived is dependent upon the impulse pattern. The suggestion was that there seems to be no reason why both theories should not be partially correct.

Some pain is undoubtedly useful in that it encourages self preservation. On the other hand, pain can be pernicious and useless, and it can occur in the absence of disease or other symptoms—trigeminal neuralgia is such an example. The word "pain" is derived from the Latin "poena" which means punishment (*18*).

Pain Response

THE response to pain is another consideration among those concerned with pain research. Pain response is a secondary phenomenon as opposed to the primary, subjective sensation of pain *per se*. The response, however, may well be the more significant, for it colors and affects the way the individual suffering the pain relates to the world. Pain response affects his occupational, social, perceptual, and in general, his behavioral articulation with society.

When different individuals suffer the same degree and kind of tissue damage or noxious stimuli, the most casual observation reveals obvious differences in response. This is true even in the experimental laboratory where the operative effect of otherwise intervening influences and variables is minimized. The question has been raised as to what it is to which the individuals are responding. Does a certain amount of tissue damage "feel" different to different individuals, or do individuals respond differently to the same feeling?

Cultural Bases of Pain Response: Illustrative Cases

THAT cultural patterns can affect and possibly reverse what is considered common and appropriate pain response is indicated by the widely read anthropological novel by Ruesch entitled *Top of the World*. The culture of the Polar Eskimo, he noted, encourages laughter as the most acceptable response to pain.

Keele (*12*) cites the French surgeon Rene Leriche's observations of Russian Cossacks in World War I. The surgeon, by invitation of some Russian officers, dislocated the joints of the hands and feet of Cossack soldiers without an anesthetic and without complaint from the men.

Although meagre by comparison with the amount of literature dealing with other aspects of pain, much has been written suggesting that pain is influenced by a number of variables in addition to tissue damage. Poser (*21*) suggests ethnic origin as one of the possible sources of variation in pain response.

Zborowski's study (*28*) is perhaps the best known and most frequently cited relating socio-cultural background to pain response. He compared pain responses of Jewish, Italian, Irish, and Old Americans. The latter group consisted of individuals who were predominantly of Anglo stock and had lived in the United States a number of generations. The Irish data were not reported in his paper. Sternbach and Tursky (*25*) also utilized the same ethnic groups in a study of psychophysical and skin potential responses to electric shock. Sherman and Robillard (*23*) studied age in relation to pain sensitivity among three ethnic groups—French, Jewish, and Anglo-Saxon. Lambert, Libman, and Poser (*14*) studied the relationship between group membership and pain tolerance. Jewish and Protestant female subjects were used. Melzack (*19*) discussed the relation of pain perception to previous pain experience and also cited studies of childbirth in primitive cultures for purposes of comparing pain response in our major American culture.

In some situations, response to tissue damage and presumably pain seems to transcend national or subcultural patterns in favor of cogent situational determinants. Beecher's (*2, 3*) well-known studies of seriously wounded soldiers in combat-zone hospitals compared with male civilians who had under-

gone major surgery revealed sharp differences in response to comparable tissue damage. Beecher attributed the difference in response to the significance of the wound to the men in question. The soldier perceived his wound as a blessing. It enabled him to escape the battlefield and to leave with honor. It was his ticket out. The civilian, on the other hand, perceived his "wound" as a calamity. It was painful and disabling. Only one-fifth of the post-operative patients refused medication for the relief of pain, whereas two-thirds of the wounded soldiers refused medication.

Another example of the influence of context or situational determinants was the common observation by medical personnel during World War II concerning the bravery of soldiers suffering from severe wounds. In contrast, they were observed to respond emotionally to the point sometimes of tears over the unwelcome prospect of daily antibiotic injections.

A study of ethnic differences in pain response conducted by Christopherson (*6*) indicated significant differences between Mexican-Americans in the Southwest, particularly Arizona, and Anglo-Americans in the same area. Subject interviews and the Petrovich Pain Apperception Test (20), a projective device, were used to obtain the data.

One of the early studies on cultural factors in pain response by Josey and Miller (*11*) and a later replication by Christopherson (*6*) of the earlier study found differences in pain response when the independent variables were race, sex, and social class. In the latter study physicians from 48 states responded to the questionnaire comparing the various groups.

The account of the cultural basis underlying response to disease was sharply drawn by Lyle Saunders in his book *Cultural Differences and Medical Care* (*22*). Saunders dealt principally with the Spanish-American folk medicine culture and contrasted the responses with those of the Anglo. The implications for prevention of disease and disability along with delivery of medical services were striking.

An example of a people-oriented technique, which has been very promising in its degree of success with individuals suffering from chronic pain, is that described by Fordyce, *et al.* (*9*). This approach employs a learning-type model in pain management, and the actual technique is that of behavior modification through conditioning techniques.

An understanding of the cultural background of the patients should facilitate the application of such techniques among the various groups in which chronic pain is particularly significant. The residents of rural areas might well be such a group.

The Rural Context

ONE of the most rural of America's peoples is the reservation Indian. Of course Indian groups differ widely in this respect. The Papago Indian of southern Arizona provides an accessible example of a culture with an almost totally different system of causality and response. Underhill (*26*) provides a good descriptive account of the Papago view of things. Christopherson (*7*) studied the Papago pain response in considerable detail and recorded information, which was unique to these people. If the culturally uninformed medical practitioner or the social service person was not aware of this information, he could make blunder after blunder on very logical bases from the standpoint of our own medical technology and social norms. The fact that this extremely large reservation is in very close proximity to the two largest urban centers in Arizona multiplies the probability of cultural conflict. When the rural Papago's physical symptoms bring him in contact with the medical technology of the urban Anglo, the result could very easily be suboptimal from the standpoint of either culture.

A cross-section of rural America reflects a panorama of ethnic and racial variation representative of all the world's continents and most of their parts. While it would be overstating the case to suggest that the majority of rural people bear the indelible stamp of corresponding Old World traditions, there is evidence that rural people have different reactions to stress, the origin of which seems to be rooted in their cultural background. A review of some of this evidence indicates the advisability of medical and paramedical practitioners to familiarize themselves with the regional ethnic and folk traditions relevant to their area of coverage. To have misconceptions concerning the nature, origins, or significance of pain symptoms may not be critical for the urban resident whose work situation may not depend on his being physically fit. The rural resident, particularly the small-scale rancher or farmer, however, cannot well afford such a luxury. It is important that he achieve and maintain optimal functioning capacity. He must be properly informed and must receive appropriate medical and supportive services when needed.

The work by Kraenzel (*13*), Stephens (*24*), and Lassey (*15*) in rural Montana also points up the need for a better understanding of the assumptions, customs, and exigencies underlying the behavior of rural people. At the same time, any conception of rural residents as being culturally uniform belongs to ages long past. The cultural diversity among the rural population precludes stereotypes and simplistic characterizations.

Kraenzel, Stephens, and Lassey conducted their research in the broad sweep of the Great Plains and the Western Mountain regions. Kraenzel (*13*) coined the term "the social cost of space" to illustrate the relative disadvantages that accrue as the result of geographic isolation. Stephens (*24*) writes:

> By accepting lower quality services, postponing needed services, and, indeed, completely doing without services in many cases due to expense or unavailability, persons in isolated areas have lowered their potential to adapt to change. They readily accept and pass on to their children (who more and more are headed for the cities) the handicap of inability to compete in areas where "good" education and "high" skills are necessary for economic success. The facts seem clear; individuals from rural backgrounds are less able to be trained, retrained, or accupationally rehabilitated. They are less likely to accept innovations in medicine, education, technology, business methods, etc., than are those from urban backgrounds. These aspects of rural personality represent real costs that result from the decision to trade interaction for space. These costs are not levied on the single individual; they are carried by all the members of the society in the form of higher taxes, decreased productivity, and general ineffectiveness in attaining certain social and economic goals for the society as a whole.

In some areas of Montana, an individual must travel 125 miles or more to reach the nearest medical complex. In this kind of a situation it would be revealing to know how often medical care and other important services are put off or not sought at all because of the costs involved. Stephens (*24*) indicated also that in his study of the social costs of space in Montana that he had reason to believe that in medically oriented matters, people in sparsely populated areas, tended to define the situation in peculiaristic ways.

A somewhat different conception of the people in a rural area seems to derive in part by observation

in a different region. Vidich and Bensman's (27) characterization of Springdale, New York as a rural area emphasizes ". . . direct and personal and human feelings that guide people's relations with each other." Springdalers are concerned with mutual assistance patterns, friendliness, neighborliness, and so forth. Borrowing and "lending back and forth" is a popular sanction for one's everyday interaction with others. The norm is a primary group-type relationship with others in the close-knit rural community. Springdalers believe ". . . that the future hope of American society lies in rural life because it has resisted all 'isms' and constitutes the only major bulwark against them."

It could be argued that the perception of medical need or the tolerance of pain has a strong economic determinant. People with adequate incomes will tend to reduce the cost of space by traveling farther for medical services. Adequate income usually bodes higher levels of educational achievement, which, in turn, help sensitize individuals to more alternatives to poor health or unnecessary suffering. Geographic isolation, low income, or peculiaristic folk medicine traditions all could combine to reduce the number and quality of feasible alternatives to pain. Both the problems of pain alleviation and the general delivery of medical services in rural areas were discussed in a seminar sponsored by the Farm Foundation in Chicago, March 2–3, 1971. Research in these areas is expected to increase in both scope and intensity in the near future.

The target areas in rural development are usually those associated with rural poverty. It is here that problems cluster. However, pain, being perhaps the most democratic and universal of all afflictions, sparing neither migrant laborer nor wealthy rancher, might provide a very useful focus for research with the rural populations. In addition to the utility such studies would have in their own right, they might well unlock some doors to fortuitous information concerning the culture of rural areas about which only speculations can be made at present.

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Rural vs. Urban Living

THE relative merits of the city and the countryside as places of residence have been a matter of debate since early times. Here are a few selected quotations from famous figures in history who obviously preferred life in the city.

"The first requisite to happiness is that a man be born in a famous city."—*Euripides*

"How can he get wisdom who holdeth the plow?"—*An early prophet in the Book of Ecclesiasticus*

"I have no relish for the country; it is a kind of healthy grave."—*Sydney Smith, 18th century British essayist*

"It makes but little difference whether you are committed to a farm or a county jail."—*Henry David Thoreau*

Proponents of the rural scene have expressed their philosophy in equally strong fashion.

"The agricultural population produces the bravest men, the most valiant soldiers, and a class of citizens the least given of all to evil designs."—*Pliny, the Elder*

"Cities are the sink of the human race."—*Rousseau*

"Good farming; clear thinking; right living."—*Henry A. Wallace*

"The rural population is America's safeguard against foreign 'isms' and crackpot programs."—*Ezra Taft Benson*

—*Compiled by Calvin L. Beale, USDA*

Agriculture's Hidden Iceberg

Agricultural Practices and Water Quality, Ted L. Willrich and George E. Smith, Eds., Iowa State University Press, Ames, IA., 415 pp. 1970. $7.95.

IN this issue, *Agricultural Science Review* breaks an 8-year tradition of consistently declining to publish book reviews. The policy was based largely on the premise that such a regular feature would be hard to maintain because of the difficulty of finding agricultural books worthy of our attention. Furthermore, those books that do deserve coverage, we noted, usually are well reviewed in other journals.

Two factors, however, made us change our mind and permit an exception for the subject book: (1) Its outstanding quality and the urgency of its message, and (2) the fact that it seems to have escaped the attention of the agricultural press.

Readers are fortunate that the authors of *Agricultural Practices and Water Quality* kick the traces and do exactly what the preface says they were not supposed to do: Express opinion not based on established research facts. This quality alone makes the book worthy of close reading.

To explain this anomaly, we should first describe the circumstances that led to the publication of the book. Actually, it represents the proceedings of a Midwest conference on "Agriculture and Clean Water," held November 18–20, 1969, on the campus of Iowa State University. The conference was an outgrowth of an earlier meeting at which research leaders decided there was a need for an exchange of ideas and an understanding of the basic processes relating to agriculture as a source of water pollutants. What came out of this conference was a great wealth of factual material and some of the most innovative ideas ever offered on the agricultural degradation of water quality.

It was a statement of one of the authors, for example, that led to our choice of a title for this review. Iowa State law professor N. W. Hines says that the highly publicized forms of agricultural pollution—like the tip of an iceberg—"signal the presence of a much larger mass of pollution that exists just below the surface of visibility." Hines predicts that agriculture's more subtle contributions to pollution will eventually require legal constraints.

One of the discussants in the workshop segment of the session on soil sediment (which fortunately was recorded verbatim) startled conference participants when he ventured the opinion that clearing up the water in the Missouri River is causing injury to conservancy dams because there is not enough silt in the water! From the way your reviewer interpreted the discussion that followed, this innovator appeared to have convinced the group that he was right.

It is unfortunate that the other workshop sessions were not recorded verbatim. Instead, readers are given sterile summaries that seem somewhat less than satisfying. Thus, the discussion section on soil sediment, led so skillfully by George M. Browning, stands out as one of the highlights of the book.

We were intrigued by the comments of Jacob Verdun, Southern Illinois University, about animal waste disposal. Advocating a return of the practice of spreading manure on the land, he argued that if the Government could pay farmers for not raising certain crops, it should consider paying feedlot operators for not lagooning animal manure. He cited the benefits of trace elements, vitamins, and soil conditioners which manure has and chemical fertilizer does not. Our problem today, he reasoned, is that everyone looks on animal manure as a disposal problem and therefore we seek the least expensive means of disposal. Instead, if agricul-

turists would regard manure as a resource, then the problem is one of transportation and application—not disposal.

It was somewhat of a revelation to your reviewer to learn in this book that the crowded Eastern seaboard megalopolis with its 30 to 50 million people is "small townish" in terms of gross organic pollution as compared with the Missouri River Basin, where organic loads from livestock are equivalent to a population of 80 to 100 million people. This statement comes from John M. Rademacher, who at the time of the conference was regional director of the Missouri River Basin region, FWPCA. Rademacher likened the urgency of the situation in agricultural pollution to a bit of philosophy by Aristotle: "To be half right on time may be more important than to obtain the whole truth too late."

To a reviewer with vegetarian tastes, the opening lines of the book were somewhat of a shocker: "We Americans are carnivorous. The average person's dinner plate accounts for 238 pounds of flesh per year." These lines came from the opening paper by Cecil H. Wadleigh and Clarence S. Britt who discussed the issues in food production and clean water. Their reference to the carnivorous tastes of Americans, as one might expect, provided a takeoff point for some cogent points about the animal waste disposal problem. Dr. Wadleigh has demonstrated many times before in similar papers that he not only knows his subject but also has fresh, innovative ideas. This paper is no exception.

Despite the premise originally set up for the conference—just the facts, please—it came as no surprise to us that some of the authors ventured a personal opinion or two. Anytime you get a group of top scientists together discussing topics in which they have an avid interest, it is only natural for their philosophical nature to creep out. And in every case, their audience is all the wiser and better for it. This is just one of the qualities of this book which we thought made it eminently worth reviewing.

The book is divided into six major sections: sediment, plant nutrients, pesticides, animal wastes, agricultural pollution implications, and agriculture's involvement in polluted and clean water. There are 26 papers, or chapters, in all. Since there was a time lapse of about a year between the conference and the date of publication, some of the statements and organizational references in the book are naturally out of date. This is to be expected, of course, in an area of science where things are moving so rapidly.

In our opinion, *Agricultural Practices and Water Quality* should be required reading for anyone—student or administrator—who is involved in environmental research or action programs.—W. W. K.

Poultry Manure Utilization

ENGINEERS and poultry scientists at the Pennsylvania Agricultural Experiment Station have developed a new system for the handling, disposal, and utilization of poultry manure.

High velocity air circulation and a special stirring and cleaning mechanism improve the physical condition of the droppings and inhibit the growth of anaerobic bacteria that generate nauseating gases. A two-stage drying system reduces moisture content of the manure to about 10 percent and produces a fine, powdery product with no offensive odor that can be stored in a bin for later use as bulk fertilizer or packaging.

The final dried product is about six times more concentrated than fresh manure and can be compared to a 5–3–2 commercial fertilizer. Moreover, it contains 17 percent calcium oxide, 1½ percent magnesium oxide, and essential trace elements. Its pH is above 7.

In field tests with crown vetch on spoil banks and highway right-of-ways, results showed that an application of 800 to 1,000 pounds of dried poultry manure per acre was a satisfactory replacement for lime and commercial fertilizer.

The Penn State system is expected to open new channels to utilize the huge quantities of poultry manure produced on farms.

Science in Agriculture, 18:3

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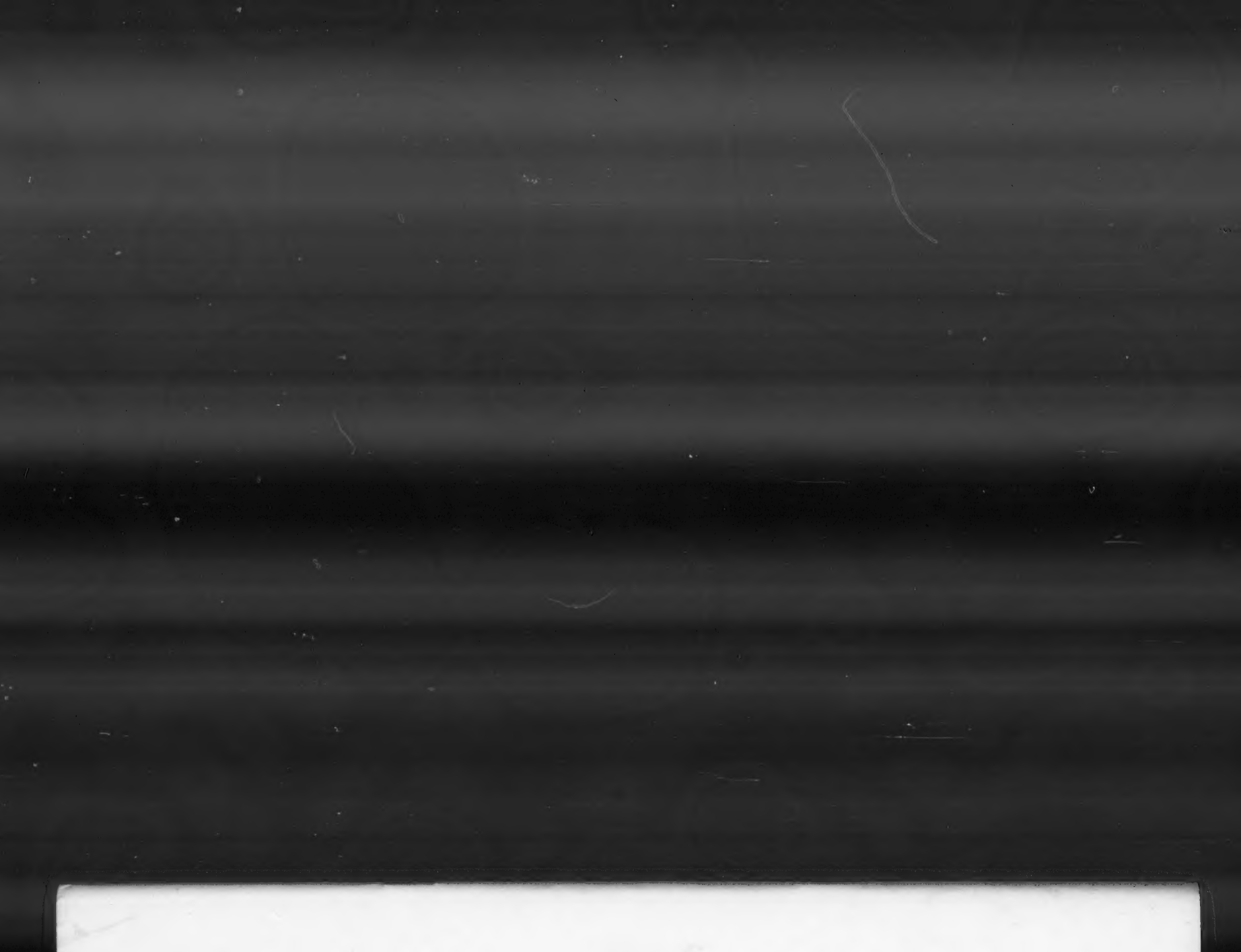
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